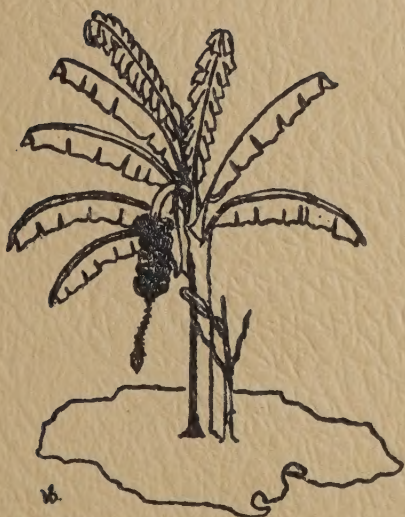


BANANA BOARD RESEARCH DEPARTMENT

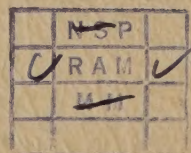
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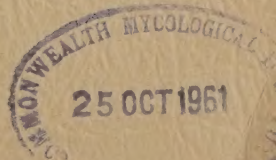
1960



10 SOUTH AVENUE, KINGSTON GARDENS
KINGSTON, JAMAICA.



August, 1961



BANANA BOARD RESEARCH DEPARTMENT

"Fontabelle",
10 South Avenue,
Kingston Gardens,
Kingston, Jamaica, W.I.
19th June, 1961.

The Chairman,
Banana Board.

Dear Sir,

I have pleasure in submitting the Annual Report of the Research Department for the year 1960.

Yours faithfully,
(Sgd.) R. LEACH,
Director of Research.

BANANA BOARD RESEARCH DEPARTMENT
ANNUAL REPORT



1960.

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I. INTRODUCTION

The year was notable for the extensive rains experienced over most of the island from July onwards which resulted in the bananas being subjected to the worst leaf spot weather since 1955. An exception was the Parish of St. Mary which again suffered from drought in September and October after which two months' heavy rains were followed by the severe winds that did considerable damage to bananas throughout the island without, in most cases, causing sufficient blowdowns to warrant insurance payments. Growers refrained from doing much cutting back and the combination of adverse conditions resulted in the bananas throughout the island ending the year with checked growth.

Considering the difficult conditions experienced for spraying, leaf spot (*Mycosphaerella musicola*) was kept under good control by oil both with aerial applications and by mechanical knapsack mist spraying which is now largely confined to that undertaken for growers by the All Island Banana Growers Association. Scattered, unaccountable breakdowns in control were experienced towards the end of the year and these shook the confidence of a few growers in regard to the effectiveness of the new oil used after the beginning of September. In most cases the breakdown could be related to irregular spraying cycles or to growers tempting Providence by reducing their applications of oil below a reasonable margin of safety.

Although not strictly applicable to this report it is worthy of mention here that the situation ultimately became confused early in 1961 by some severe outbreaks of Premature Yellows in the dry, early months of the year and slow, winter growth tended to encourage the yellowing of banana foliage associated with the slight phytotoxicity of spray oil.

The outstanding feature of the Department's activities was the launching of a campaign to demonstrate the extensive damage being done to bananas throughout the island by the burrowing nematode (*Radopholus similis*). This was possible for the first time because, after completing work started in Central America, the nematologist was able to demonstrate the value of planting nematode free suckers into soil free of *Radopholus*. He succeeded where chemical control measures had failed in experiments carried out extensively by the Pathologist in Jamaica. Growers were surprised to discover how severely suckers could be trimmed to free them of nematodes and yet still survive the treatment. At the same time the nematologist found that, unlike most nematodes, *R. similis* appears to be specific to bananas in Jamaica so that fallowing or crop rotation is a comparatively simple, if expensive, method of starving out this nematode in the soil.

The Assistant Pathologist successfully elucidated a problem which has baffled scientists associated with banana growing in Central America and the West Indies for several decades, namely, the cause of a spotting of the fruit, in the field, which has been known by various names such as fruit spot, speckle and swamp spot. He found that the disease, serious in some seasons, is caused by the fungus, *Deightonella torulosa*, which occurs commonly on dead banana leaves. The aetiology of the disease has been studied largely with the aid of extensive spore trapping. Control measures, even if difficult, can now be based on facts.

Another commendable though perhaps not so important a discovery was made by the Soil Chemist regarding a leaf spot disease which has been known to occur in localised patches of bananas for many years without spreading to cause concern to growers. This black spot disease is also caused by *D. torulosa* but it is only found on bananas, in this case, suffering from acute manganese deficiency associated with high alkalinity. In the absence of conditions favourable for infection by *D. torulosa* the symptoms of acute manganese deficiency have been clearly demonstrated for the first time on bananas.

The Physiologist has been largely concerned with work on the control of grasses in banana plantations as this is increasingly important now that selective weeding is becoming popular with growers, not only for improving fertility but also as a means of overcoming the high cost of clean weeding.

Since the nematologist has claimed that the banana burrowing nematode cannot exist in the soil for longer than 2 months in the absence of its living host, much emphasis has been laid on the necessity of finding a rapid method of killing bananas to enable replanting to be done safely but as quickly as possible.

Now that a standard technique has been decided upon for sampling banana leaves, the Analyst has been able to accelerate work on correlating foliage analysis with soil analysis and the results of fertilizer experiments.

Prior to 1960 research with Breeding and Panama disease was divided between the Imperial College of Tropical Agriculture and the Department of Agriculture, Jamaica.

Fundamental research and male parent breeding were done in Trinidad, and the production of tetraploids by crossing with Gros Michel and the testing of such progeny were done in Jamaica.

Commencing April 1, 1960, all banana breeding research has been centralized in Jamaica under a Colonial Development and Welfare Scheme. The Scheme is now being administered by the Banana Board on behalf of the Ministry of Agriculture and Lands with the aid of the staff which was employed by the Banana Breeding Scheme at the time of the transfer.

Grateful acknowledgments are recorded here to all those kind people who have given assistance to the Research Department throughout the year, including growers and members of the staff of the Ministry of Agriculture and Lands, the Sugar Manufacturers' Association, the All Island Banana Growers Association and the Jamaica Agricultural Society.

II. REPORT OF CROP PHYSIOLOGIST (E. A. TAI)

Construction work on the extension to the laboratory building came to an end during the year and it became possible in December for the Soil Chemist to transfer to the new Soils laboratory much of the Soils equipment formerly housed in the Physiology Section. With the physical separation of the laboratories there inevitably occurred a change in staff relations but close liaison was maintained with the newly established division of the Department and the sharing of the use of several items of apparatus, equipment and other facilities was continued.

There were several changes in junior staff personnel; nine resignations among Junior Technical Assistants in the laboratory of the Analyst with only six replacements resulted in there being three vacancies at year's end. The posts were advertised and a number of applicants interviewed but appointments were not actually made before 31st December. The Junior Technical Assistant in the laboratory of the Crop Physiologist was advanced in grade in July.

The Crop Physiologist was required to assume administrative responsibility for the Department during the absence of the Director of Research on overseas leave, 20th June to 24th August. In this period arrangements were concluded for the presentation at the FAO meeting at Abidjan 12-19 October of 9 papers prepared by specialists in the Department.

Among notable visitors directly concerned with banana research during the year were Drs. Steward, Barker and Mohan Ram from Cornell University, Drs. Freiburg and Brun of the United Fruit Company's Norwood Laboratories, Srs. Lozano and Gambarotti of Asociacion Nacional de Bananeros del Ecuador and Mr. D. Rhind of the Colonial Office.

The work of the section followed the general pattern laid down in 1959 with variation in emphasis and additions to the original programme dictated by the urgency of ad hoc problems at different times and the availability of facilities for undertaking investigations planned. Field experiments were concluded at 7 sites and at 7 new sites additional projects were initiated with the co-operation of growers.

A. Nutrition of the Banana Plant

(i) **Foliar analyses:** The analysis of samples collected in 1959 was completed and a technique based on the results adopted generally for leaf analysis work in the Department. Plants in a stage of vigorous vegetative growth are selected for sampling and a portion of lamina measuring about 2 feet is taken from the middle of the leaf to the left of the midrib as viewed from below. However, while this method has constituted standard practice in those investigations making use of leaf analysis, research into means and ways of refining the procedures so as to achieve greater accuracy was continued. Details are given in the report of the Analyst.

(ii) **Nutritional disorders:** The condition of an excessively high concentration of potash in the leaves of bananas growing on an old ash dump was reported in 1959. Treatment of the area with a number of soil amendments was begun in January but observations on the responses obtained were possible only up to the beginning of June when the plants were washed away by floods and several inches of silt deposited on the field. At that time plants growing in plots to which powdered gypsum had been applied at the rate of 3 cwt/acre showed a decidedly better appearance than others treated with kieserite, sulphur or the controls and also showed lower leaf potassium with increased calcium and magnesium.

A blotchy chlorosis followed by interveinal necrosis on the leaves of young plants 3-4 months old occurred in a number of fields subjected to sprinkler irrigation on the St. Cath-

erine plains in January and February. The symptoms suggested a mineral deficiency but analysis of soil and leaves showed no significant differences between affected and unaffected areas in the same field. There was no apparent results ascribable to any of a number of treatments including application of "minor elements" as chelates. The condition cleared completely before the plants were 6 months old although no striking change in the composition of the leaves was revealed by analysis.

The characteristic Premature Yellowing of bananas growing under conditions of limiting soil potash was observed to accentuate the injury caused by Sigatoka in several instances in Portland and St. Mary. Application of potash fertilizers resulted in improved vigour of the plants and apparently increased resistance to Sigatoka as spray cycles could be lengthened without deterioration in control of the disease.

(iii) **Nutrient uptake:** The inconsistency of the response obtained to phosphate treatments in the 3 x 3 x 3 fertilizer trials stimulated interest in the questions of phosphate uptake by banana plants under different conditions. It was not clear whether any of the phosphate supplied as fertilizer had been utilised by the plants. Arrangements were therefore made to carry out analysis of leaf samples taken at regular intervals from existing fertilizer experiments and also to lay down a number of simple trials for observation of the effects of phosphate application to bananas on soils of low phosphate status.

For one of the experimental sites a field planted in June, 1959, was selected in St. Thomas. The soil, derived from Bowden Beds, was neutral to very slightly alkaline in reaction, very low in phosphate, medium low in potash, high in calcium and low in magnesium as shown in the analyses (Appendix, Phys.1). Details of experimental treatments which were superimposed on the standard practice of the estate and of the layout employed are given in the Appendix (Phys. 1). The first applications were made in March, 1960, when shooting of the plant crop was commencing and it was arranged to make observations on the ratoon crop; leaf samples were taken in June, September and December for chemical analysis.

Growth of the followers of the plant crop was uneven and by the end of 1960 only a small proportion had shot. The interim results (Appendix, Phys. 1) indicate that greater uptake of P_2O_5 , as determined by analysis of the leaves, took place in the plots receiving additional phosphate fertilizer in the form of di-ammonium phosphate; this was not reflected in growth of the plants, however.

Two experiment sites were located on acid Rio Grande alluvium in Portland. On one of these half the number of plots received a dressing of di-ammonium phosphate and half sulphate of ammonia while one-half of each plot was limed with 3 tons ground limestone/acre. The layout is given in the Appendix (Phys. 2). The field had been planted in September, 1959, but the development of the plants was backward; even at the end of the year shooting of the plant crop was incomplete although a number of the first ratoons had actually matured fruit. The first application of treatments was made in April, 1960, and leaf samples were collected for analysis in August.

The results tabulated in the Appendix (Phys. 2) show that leaf phosphorus was higher on the plots to which phosphate fertilizer was applied; this did not, apparently, have any effect on the yield. Liming seemed to suppress uptake of P_2O_5 in a number of the plots.

In the other Portland experiment applications of lime, kieserite and kieserite together with di-ammonium phosphate were compared in plots demarcated in duplicate in a field of very poor-growing bananas planted in May, 1959; all plants received a basic dressing of complete fertilizer. The treatments were commenced in April, 1960, at which time none of the plants had shot and there were still several gaps to be supplied. The results of leaf analysis done in August are given in the Appendix (Phys. 3) and show greater uptake of P_2O_5 in the plots receiving extra phosphate. The limed plots appeared to grow more vigorously than the others at all times.

No general conclusions can safely be drawn from these experiments at this time. It seems clearly evident, nevertheless, that uptake of P_2O_5 by bananas is increased by the addition of phosphatic fertilizers to the soil. In the absence of definite yield responses ascribable to the extra P_2O_5 the possibility of so-called luxury consumption may be envisaged though closer examination may reveal effects having a direct bearing on productivity.

B. Sucker Production

(i) **Gibberellin trial:** Results of the trial at Bodles to determine the effect of gibberellin applications to planting material on production of suckers showed that all gibberellin

treatments affected growth adversely. The initial germination rate was reduced, to the greatest extent by dipping in 100 ppm GA solution, and subsequent growth continued abnormal up to eight months from planting when shooting commenced among the controls; the first leaves had reduced laminae and the pseudostems were slender when compared with typical banana plants of the same age in the same field.

Sucker growth was suppressed in those instances where the higher concentrations of GA were used and the effects were more noticeable with solutions than with pastes as may be seen by reference to the table (Appendix Phys. 4) in which are given the numbers of suckers obtained at the end of October, 1960, when the experiment was concluded.

(ii) **Pruning trials:** About 30% of the plants in the trial at Bodles were blown down by a local windstorm in October; the remainder of the plants were completely wrecked by the "northers" which prevailed in early December so that the experiment was brought to conclusion at that time.

The observations of 1959 were confirmed; there were more suckers produced with greater frequency of the pruning operation and also with earlier 'selection' of the follower. Regrowth of cut suckers contributed relatively little to the totals of the different treatments as "plucking" was the technique adopted for pruning throughout. In those plots where the followers were selected in April and August there was greater uniformity in growth than in the others; where the first suckers were selected as followers an uneven appearance was presented. The most vigorous growth of suckers was observed in May/June.

Yield was adversely affected when the suckers were allowed to remain on the mat until bulling of the parent. Selection of the follower at an early stage in the cycle of development gave superior results in count bunches and also weight of fruit (Appendix Phys. 5).

An experiment to test the effectiveness of "chemical pruning", the suppression of unwanted sucker growth by application of chemicals, was initiated at Golden Vale, Portland, in February, 1960. Two Latin Squares were laid out in a field of first ratoons with the following treatments applied to plots of 18 mats each.

1. Standard pruning by plucking unwanted suckers
2. Cutting off unwanted suckers at ground level
3. Cutting off unwanted suckers at ground level and smearing the cut surface with 2,4-D paste in lanolin (5% A.E.)
4. Injecting into the pseudostem of unwanted suckers 15 ml of 2,4-D solution (1% A.E.)
5. Injecting into the pseudostem of unwanted suckers 15 ml of kerosene.

The first application of the treatments was made on 29th February and there were repeat applications on 23rd May and 12th September.

Within a week of treatment those suckers injected with kerosene had wilted; the aerial portions died and rotted down to the corm in six weeks. The pseudostems of the suckers injected with 2,4-D solution broke off at the junction of the leaf sheaths with the corm ten to fourteen days after treatment; rotting did not occur as with kerosene injections. Where the cut surfaces were smeared with 2,4-D paste they blackened and no further growth was observed on the treated plant although the tissues remained alive. Regrowth of suckers cut off at ground level and left untreated was quite rapid, cut suckers regaining a height of two feet in as many weeks, but in the case of plucked suckers there was usually no new growth for four weeks.

In all treatments there was no apparent effect on the shoots which were not actually treated. This absence of wide systemic action on banana on the part of 2,4-D was in keeping with the observations of other workers (Barker and Mohan Ram, personal communication) and indicates the possibility of using the chemical with safety in banana fields if care is taken to apply it only where its action is desired.

As was to be expected the number of regrowths was greatest where suckers were cut at ground level and left untreated; both injection treatments suppressed sucker growth to a greater extent than the cutting treatments (Appendix Phys. 6).

(iii) **Growth observations on "cleaned suckers":** A study of the development of plants from suckers cleaned to varying extent for elimination of nematodes were set to grow in sand after being treated in groups of six as follows:

1. Trimmed according to currently standard practice, heart left intact.
2. As above, heart gouged to encourage growth of side buds.
3. "Cleaned" fully — maximum paring done on corm.

4. "Cleaned" partially — $\frac{1}{2}$ corm pared away.
5. "Cleaned" partially — $\frac{1}{4}$ head pared away.
6. "Cleaned" partially — very slight paring only.

They were arranged in a 6 x 6 Latin Square and the decision was taken to dig out at one month intervals for observation the six plants in one row.

Sprouting commenced before the end of the first month in the suckers which received little or no paring of the corm but not in treatments 3 and 5.

C. Openhandedness

(i) **Timing the nitrogen application:** One of the two experiments initiated in 1959 was brought to conclusion in December, 1960; experimental application of fertilizers was completed by June and the area reverted to standard estate practice but observations were continued beyond the end of the plant crop in July until most of the first ratoons had been reaped. Nearly all of the bearing plants were blown over by a local windstorm the second week of December. The results showed a highly significant difference in the incidence of openhandedness between bananas receiving nitrogen applications throughout the crop and those to which the full quota of nitrogen was applied before flowering (Appendix Phys. 7). There was no remarkable effect on the yield from any of the treatments and, apparently, openhandedness was not affected by the source of nitrogen.

In the other experiment the uneven growth of the plants rendered necessary a modification of the treatments originally planned. As the experiment was sited in an area where the first crop of bananas is normally reaped within 12 months from planting the nitrogen applications for the year were timed as follows:

- A. throughout 12 months,
- B. planting to six months after,
- C. six months to 12 months after planting.

The last application of experimental fertilisers was made in July, 12 months from planting but reaping of the plant crop was not complete even at the end of December although a large proportion had matured by August. The results tabulated in the Appendix (Phys. 7) do not show any statistically significant differences with regard to the effects of the treatments on yield or openhandedness. Visual observation indicated that the fruit from plots receiving nitrogen in the latter part of the crop life showed a higher percentage of "poor" (unsuitable for export) than other plots.

The suckers of the ratoon crop in both experiments grew with satisfactory vigour in all plots, the absence of any remarkable difference suggesting the possibility of storage of nitrogen absorbed earlier to supply later needs in those instances in which application of nitrogen was suspended for some time. The fruit of the first ratoons showed little openhandedness.

It may be concluded from these trials that one method of reducing the incidence of openhandedness in the plant crop, in which it always occurs to the greatest extent, may be application of the nitrogen quota in the period planting to flowering. This covers the first six months after planting in the "12-month areas" of the St. Catherine plains.

(ii) **Regulating water applications:** Shooting commenced in the field selected for the observations in March, 1960. Three plots of approximately an acre each were then demarcated and arrangements made to irrigate them by flooding at the standard frequency, half and twice as frequently. A number of factors contributed to make strict adherence to the irrigation schedules impossible so that records of openhandedness in the plots could not be interpreted in terms of the effects of soil moisture regulation.

D. Fruit Investigations

(i) **Crop timing:** An experiment to explore the possibility of inducing flower production in banana by the use of Gibberellic acid and thereby rendering practicable the regulation of the crop was commenced at Orange River in November. A field of ratoons was selected and plants of approximately 6 months growth marked for differential treatment in groups of 9 to give 4 replicates of the following

1. Control
2. Single spraying with 100 ppm Gibberellic acid
3. Two sprayings a fortnight apart with 100 ppm Gibberellic acid
4. Single injection of 100 ppm Gibberellic acid into the pseudostem
5. Two injections, a fortnight apart, of 100 ppm Gibberellic acid into the pseudostem.

In spraying, the heartleaf and two next were wetted to run-off while the remainder of the foliage received a lighter application. Each injection consisted of 50 ml of solution applied by means of a special needle.

The first application of the treatments was made on 3rd November and arrangements made to carry out measurements at 4 week intervals. By the end of December it was observed that abnormal lengthening of the internodes was occurring on injected plants; there was also deformation of the lamina in new leaves. On sprayed plants there was seen a tendency to "rosetting".

(ii) **Bunch weights:** Measurement of individual bunch weights carried out each reaping since May, 1959, on fruit selected for export from a field at Darlingford in Portland confirmed the general belief that "summer" fruit weighs more than "winter" fruit. Mean weights for each quarter of 1960 are given in the following table for different sizes of bunch.

Quarter	9 hands	8 hands	7 hands	6 hands
Jan-Mar.	47.2 lb.	37.0 lb.	30.4 lb.	26.6 lb.
Apr-Jun.	50.7	40.2	32.6	26.6
July-Sep.	52.3	44.3	35.9	27.8
Oct-Dec.	45.7	42.2	30.9	24.3

The same pattern of variation in weights was observed in fruit reaped at Retirement in St. James and at Orange River in St. Mary; actual weights differed appreciably, however.

In September tests were undertaken to obtain information as to losses in weight which may be expected to occur when bananas are held under normal atmospheric conditions for some time after cutting. Fruit reaped at three locations

1. Bodles — irrigated lowland
2. Caenwood — unirrigated lowland
3. Orange River — unirrigated medium upland

were held in typical "banana stands" and weighed at 8, 24 and 48 hours after cutting. Three grades of fullness — $F\frac{3}{4}$, $LF\frac{3}{4}$ and $\frac{3}{4}$ — were used and the fruit was taken from oil-sprayed, Bordeaux-sprayed and unsprayed fields.

The results indicated that little loss occurred in the first 24 hours but may assume importance thereafter, especially from unsprayed sources. It was observed that the rate of loss did not appear to be significantly affected by location, bunch size or grade nor was there any difference between oil-sprayed and Bordeaux-sprayed fruit in this respect; fruit from the unsprayed area lost weight at an appreciably higher rate than that observed with fruit from sprayed areas. This is shown in the table given in the Appendix (Phys. 8).

(iii) **Effects of oil spraying:** The comparisons, commenced in 1959, of measurements made on fruit from Bordeaux-sprayed, oil-sprayed and unsprayed plants were continued to the end of December, 1960. Differences in weight of bunch were inconsistent, variation within each group being in excess of that between groups when bunches having the same number of hands were compared. Counts of the fingers held by hands at the butt and tip ends of bunches revealed no significant differences ascribable to spray treatments. This was also observed in the case of measurements of the mean lengths of fingers although there was a tendency for oil-sprayed bananas to show greater finger length. These results are shown in a table given in the Appendix (Phys. 9).

Mean weights and volumes of fingers were taken for fruit of different grades of maturity; assessment of these was according to "commercial" standards which permitted a wide margin of error and involved considerable overlapping. The results indicated the increase in weight with rise in grade but significant differences were not observed to occur between fingers as a result of the spray treatments; weather conditions prevailing for some time preceding the time of reaping had a marked effect on finger weight, however, as all grades cut during and after August/October drought had appreciably lighter fingers than others cut during the rest of the year. There was an increase in the weight to volume ratio as the grade became higher but no variation in this ratio apparently resulted from spray treatments (Appendix Phys. 10).

"Dry matter" content of the fingers followed the pattern of the other measurements (Appendix Phys. 11). The determinations were made by drying at 86°C to constant weight samples of 20 fingers each from each lot of fruit on which other measurements were made.

(iv) **Latex staining:** As a part of the co-ordinated attack on the problem of latex-staining which is responsible for disfigurement of a large proportion of the fruit exported to the United Kingdom a search was undertaken for an effective method of removing the latex from the surface of banana fingers without causing damage. It is known that the unsightly brown discolouration develops from the oxidation of "latex" in air and the use of baths containing a proprietary antioxidant was tried to prevent this without conspicuous success. Although various surfactants were incorporated in the baths the latex could not be removed unless some degree of mechanical scrubbing was applied even when the treatment was done before the latex had dried.

In another approach to the problem simple tests to determine the possibility of reducing the extent to which styles persist on Lacatan banana fingers were initiated. For the purpose, screening of compounds used for fruit thinning and reduction of foliage was begun in December.

(v) **Adherence of PEPS:** The fungicidal paste used to treat cut ends of fruit stalks has been found to wash off when exposed to rain. It transpired that greater adherence was obtained from paste to which 0.1% Triton X-114, a proprietary spreader used in spraying with Bordeaux mixture, was added than from the paste without additive. An account of the experiment is given in the report of the Analyst.

E. Weed Control

The success of high-volume spraying with dalapon in the control of grass weeds in banana fields prompted investigation of low-volume applications. On 29th June an experiment to compare different rates was laid down in a grass-infested field at Belvedere Estate in St. Thomas while observations on a large scale were carried out in the same connexion in collaboration with the estate owner.

From the results obtained (Appendix, Phys. 12) and observations made in different fields on the estate, it was clear that low-volume spray applied with a Knapsack mist-blower could be as effective as standard high-volume spraying with hand operated pneumatic sprayer in controlling grasses. One of the most noxious grass weeds of the area, Para grass (*Brachiaria mutica*), proved to be more easily killed than several others; Flat grass (*Axonopus compressus*), Bahama grass (*Cynodon dactylon*) and Guinea grass (*Panicum maximum*) were also quite easily killed but Rice grass (*Roettboellia exaltata*) proved resistant. The maximum effect of a single spraying was observed at 10 to 14 weeks after the application and occurred earlier with the high volume.

On the basis of the Belvedere experience low-volume spraying with dalapon at the rate of 2 lb. in 2½ gallons to the acre is becoming standard grass control practice in St. Thomas banana fields.

F. Photography

Production of monochrome photographs for the Departmental files and for use in illustrating publications prepared by specialist officers was maintained in the darkroom. There were 461 final prints made by the Technical Assistant in charge of the work. The processing of colour photographs on behalf of the Department was done by commercial establishments.

G. Advisory Work

In co-operation with the field services of the All Island Banana Growers Association, advice on planning of fertilizer schedules was given to several growers; this was based largely on the chemical analysis of soil by the Soil Chemist and the results of fertilizer experiment conducted by the Agronomist. Cyclostyled leaflets on buying of bananas by weight and spacing of Lacatan banana were prepared for limited circulation. In addition, some guidance was given the officers of the Jamaica Agricultural Society in the compilation of their Extension leaflets on banana growing.

H. Reports and Publications

Special reports on loss in weight of bananas left to lie for varying lengths of time after cutting and suppression of weeds by the use of black polyethylene sheeting were prepared. A paper on "Openhandedness of Lacatan Banana" was written for the FAO meeting at Abidjan and one, "Chemical Control of Weeds in Banana Fields", for publication in the second issue of "Information", the organ of the Scientific Research Council.

III. REPORT OF SOIL CHEMIST (C. G. JORDINE)

A. Laboratory

Despite changes in the laboratory staff of the Soil Section during the early part of the year, approximately 5,200 determinations in duplicate were carried out on soil samples taken in the survey of banana fields together with those taken for the basis of fertilizer recommendations to growers. Construction was started on a new laboratory to house the Soil Section. Owing to delays the building was still incomplete at the end of the year. However, the personnel in the Soil Section moved into this more spacious laboratory which more than compensated for the handicap of incompleteness.

B. Survey of Banana Fields & Soils

In previous Annual Reports of 1956 and 1957/8 the aim and procedure of the survey have been outlined and observations made on the results obtained from it. In order to increase the rate of the survey soil sampling, a special Field Officer was appointed at the beginning of the year to assist with the work. However, after a closer examination of the results of the analyses obtained from the different categories of good, mediocre and poor fields it became evident that the little useful information received was not worth the expense and time involved. Added to this was the unreliability of some of the yield figures of banana fields. The survey was therefore stopped and the services of the Field Officer were terminated at the end of the year. The soil analysis figures were, however, used in many cases to supply fertilizer recommendations to growers.

C. Micronutrient Trial

The aim was to make preliminary observations on the effects of applying various minor elements to growing bananas. The treatments were started when the plant crop was near the shooting stage and the first ratoon crop was used for analysing the effects of the treatments. The experiment is still in progress. The layout, treatments and the statistical analyses on data are presented in Appendix Chem. 1.

Esminel is a proprietary trace element mixture containing 5% copper, 10% Manganese and 5% Zinc. Borax was applied as a 5% solution to the leaves.

The results indicate that none of the trace elements produced any significant response in days to shooting, height, girth at shooting and grade. The first ratoon crop suffered a severe drought and this might partly explain the high co-efficient of variation obtained.

Gratitude is expressed to Mr. H. E. Wheeler of Egypt Pen for his help in getting this trial started and also for his co-operation in carrying out the foliar spray treatments.

D. Forking Experiment

Reforking of banana fields is still practised on some of the heavier soils in Jamaica. Opinions vary among farmers and agricultural scientists as to the value of reforking and also to the type of reforking considered suitable. No reference to an experiment on reforking could be found though Osborne (1956-7) carried out a tillage experiment on the irrigated plains of St. Catherine. It was therefore decided to lay down one experiment on an area with a uniform soil type and slope in St. Mary, to compare different ways of reforking banana land and to find out their effects on the growth and yield of bananas.

The experimental design consisted of five randomized blocks comprising the following four treatments:—

1. Control — no forking.
2. Forking of a ring, about 2 ft. in radius, around each plant.
3. Forking the whole area except for a ring, about 2 ft. in radius, around each plant.
4. Forking the whole area.

Two split plots in each treatment consisted of forking, once a year and once in two years, both being forked to a depth of 9-12 inches. The records taken were leaf growth, date, girth, height at shooting; grade, weight of fruit at reaping and forking costs. The experiment is still in progress.

E. Liming Trial

This experiment was started because a grower had apparently received response to lime applied to certain sections of his plantation. The aim of the experiment is to study the effect

of liming as a corrective for soil acidity and its effect on the uptake of potash and phosphate by the banana plant on Marymount Clay. The experimental design is a 3^3 Ca x P x K factorial of twenty-seven plots with six plants to each plot. There is a basic application of Sulphate of Ammonia at the rate of 3 ozs. per root to all plants every 2 months. One application of lime was made at the rates of: nil, one-half lime requirement and full lime requirement. Superphosphate and Muriate of Potash are applied at the rate of: nil, $\frac{1}{4}$ lb. and $\frac{1}{2}$ lb. per plant three times per year.

F. Preliminary Observations on a Manganese Deficiency Disease of Lacatan Bananas

Very little is known of the effects of minor element deficiencies in the banana plant. The only reference in the literature is that relating to zinc deficiency symptoms on the Dwarf Cavendish bananas in the French Guinea (Moity, 1954). Recently, several examples of a peculiar condition of banana leaves and fruit have been observed in a few areas in Jamaica mainly on Lacatan bananas although some have been noticed also on Robusta, Gros Michel and one other variety. The symptoms are described below and evidence is presented to indicate that the disorder is due to a manganese deficiency.

(i) **Leaf symptoms:** The earliest symptom is the development of a marginal, interveinal chlorosis on the youngest open leaf or on the one next to it. The chlorosis spreads in the direction of the midrib and small, round, dark brown and black spots, the size of a pin-head, appear on the upper surface of the leaf. These spots are mainly within the chlorotic area and are greater in number towards the margin of the leaf. The few spots in the green area of the leaf usually have a dark brown to black centre with a pale yellow margin which is not clearly distinguished in the most chlorotic areas. The spots are usually confined between the veins but a few may occur on the veins. The extent of the chlorosis and the amount of spotting usually increases, some of the spots becoming 1-3 mm in diameter and coalescing. Some spots may be round but others become elongated giving rise to oblong necrotic patches as much as 2 cms wide and 3 cms long or larger. These necrotic patches usually have an orange coloured margin. A dark brown or black spot, sometimes appearing slightly raised, is usually seen at the centre of these necrotic patches which eventually join up to form a brown margin, often around the entire leaf. The margin is crinkled and drawn together, under tension, so that the leaf appears to be boat shaped, especially when untorn by wind. The leaf itself is also curved downwards. Many brown to black, circular and oval spots occur in the dead tissue.

The original chlorotic areas become indistinct as they gradually become more and more necrotic. The inner part of the leaf blade remains green but with varying numbers of necrotic spots and patches with orange yellow margins. The extent of the necrosis seems to depend upon the extent of the chlorosis. The marginal necrosis advances with the age of the leaf until eventually the whole leaf turns brown and dies. There are also innumerable, black, pin-point spots over most of the leaf. There are also black spots from pin-point size up to 2 or 3 mm in diameter mainly on the upper surfaces of the midrib and leaf bases. Some of the smaller spots may have a halo around them which give the appearance of a water soaked area, not unlike speckle, Meredith (1960 a). Meredith (1961 a) has stated that this black spotting of Lacatan banana leaves can be observed in most Jamaican plantations even on healthy foliage but they are far more numerous under the conditions described above.

A few examples of unfurling or recently unfurled leaves have shown a very marked chlorosis, followed by a marginal necrotic scorching leading to the boat shaped appearance of affected leaves, very few, if any, of the usual dark brown and black spots being seen on affected leaves. It is not known whether this was a severe case of the same disorder or some other one in combination with it. Less severe symptoms show interveinal chlorosis and dark brown or black spots with a yellow margin.

(ii) **Fruit symptoms:** Affected plants invariably produce dark brown to black scab-like spots on all portions of the bunches. Meredith has ascribed this 'unusual form of fruit spot' to infection by the fungus, *Deightonella torulosa*, which causes speckle of Jamaican bananas. In fact, on affected plants a whole range of spots have been seen, from the small, speckle spots with a water soaked halo to the large scabs, 5 and 6 mm in diameter.

(iii) **Soil relationship:** A preliminary inspection of affected areas showed that the majority of cases of this disorder were found on a soil type known as Wait-a-bit Clay, while a few cases were later found on rendzinas, particularly Killancholly Clay. The brief des-

criptions of these two soils, given below, are taken mainly from the work of K. C. Vernon, in his soil survey of some parishes in Jamaica.

(a) **Wait-a-bit Clay** is a red to strong brown (very variable) well drained soil that occurs over a parent material of deeply weathered, highly leached acid shales and tuffaceous shales, sometimes well-bedded and sometimes almost massive. It is very erodible, acidic, and of low to medium low natural fertility. It occurs in the Guys Hill, Decoy and Springfield areas of St. Mary and also in the Christiana area of the parish of Manchester as well as in and around Wait-a-bit, Trelawny.

(b) **Killancholly Clay** is a shallow dark grey brown soil which occurs on steep slopes over chalky and rubbly, impure, soft limestone in association with two other soil types known as Non-such and Carron Hall Clays. This soil type is found in many areas within and at the edge of the soft limestone plateau of the island. It is alkaline in reaction and its depth to the soft limestone varies from about 10 inches to 21 inches.

Observations on affected areas on Wait-a-bit Clay showed that in most cases the isolated patches were just beside the road and that limestones, from the road, were always present. The pattern was so consistent that the condition could be predicted whenever limestone was seen near roadside ditches in this soil type. pH values for a few of these areas on Wait-a-bit Clay are presented in Appendix Chem. 2, the affected areas being neutral to alkaline and the unaffected areas acid. On the other soil type Killancholly Clay both unaffected and affected areas were alkaline though affected areas had a higher percentage of lime in the top soil.

(iv) **Cause:** The lime or the alkalinity in the soil was evidently connected with the disorder of the bananas but these factors alone were unlikely to predispose the banana plant to attack by a fungus, as some more alkaline soils do not do so.

The pattern suggested that the alkalinity or the lime was making some nutrient unavailable to the plant. The leaf symptoms could not be compared with those described by Murray (1959) for deficiencies of the major elements. An iron deficiency could not be discounted but it was unlikely because two cases of lime-induced iron chlorosis existed in the same field with different symptoms, particularly those in the later stages of the disorder. Deficiencies of Zinc, Copper or Molybdenum were unlikely because the symptoms of Zinc deficiency as described by Moity (1954) did not match the disorder; some of the affected areas were being sprayed with Copper sulphate and lime (Bordeaux mixture) and Molybdenum is known to be more available on alkaline soils than on acid soils. There was no sign of necrosis of the growing points suggestive of boron deficiency.

The condition was in fact suggestive of manganese deficiency as this element is known to be more available in acid soils than in alkaline ones.

(a) **Foliar spray treatments:** Severely affected young plants were chosen for foliar spraying at each of three typical sites, two in the Christiana area on Wait-a-bit Clay and one at Hopewell, St. Mary, on Killancholly Clay. Parts of plants were sprayed with the following solutions:— 2% Magnesium Sulphate, 1% Manganese Sulphate, 1% Ferrous Sulphate, 1% Borax, 1% Ammonium Molybdate, 1% Zinc Sulphate and water as the control. 16 lbs. of Sulphur were applied separately to the roots of another two plants. Later a ninth treatment of a 1% Ammonium Sulphate solution was included. Although the experiment in the Christiana area had to be abandoned, the one at Hopewell has yielded significant results. The treatments were at first carried out every two months but after 4 months it was decided to change the treatments to once per month. In the case of shot plants, the fruit was sprayed as well as the foliage.

The Manganese sulphate treatments have improved the condition of the leaves of affected plants. At the time of shooting one of the plants so treated had the four youngest leaves healthy, the next three leaves slightly affected and the two oldest severely affected. The other manganese treated plant had all eight leaves unaffected at the time of shooting. None of the other treated plants have shown any improvement, with the exception of one plant sprayed with Ammonium Molybdate which showed very slight improvement. Two other affected plants were later chosen for the molybdate treatment and at the end of the year no improvement had been noted in their condition. The manganese sulphate treatment has reduced the amount of fruit scabbing considerably whereas none of the other elements have had this effect. (Appendix Chem. 3).

Another experiment, with more frequent spraying treatments was carried out on the same lines as the one just described, the plants being sprayed weekly. Within 2-3 weeks

there were definite signs of improvement in the plants sprayed with manganese sulphate and after 14 weeks the leaves were all healthy. The plants treated with the other chemicals still remained affected. Ammonium Molybdate proved highly phytotoxic in this case.

(b) **Leaf analysis:** Leaf samples were taken from sixteen affected plants and also sixteen unaffected plants in an area at Hopewell, St. Mary, on a rendzina soil. The method of sampling employed was that of Boland (1957-1958, 1959).

Analyses for Nitrogen, Phosphate, Potash and Calcium were carried out by the Analyst of the Research Department whilst analyses for percentage ash and trace elements were determined spectrographically by the Agricultural laboratories, Ministry of Agriculture and Lands. Acknowledgment is given here to the kind assistance received from the staffs concerned. The results of the chemical analyses are presented in Appendix Chem. 4.

The figures for most elements, nitrogen, phosphorus, potassium, iron, copper, boron, strontium and barium were significantly higher in the affected plants than in unaffected plants. There was no marked difference between the percentages of magnesium and of ash in both groups of plants. Calcium was just significantly lower in the affected plants. The manganese values for affected plants were very significantly lower than those for healthy plants. This coupled with the beneficial response to manganese foliar sprays is considered to confirm the cause of the disorder as being due to a manganese deficiency. From the figures presented, a level of 25-30 ppm of Mn in the second youngest open leaves of Boland's stage 2 plants may be considered an approximate figure below which severe manganese deficiency symptoms are likely to occur.

The relation of soil pH on the Wait-a-bit Clay and the symptoms previously described are also in line with the existence of a manganese deficiency, the main factor controlling the availability of manganese in the soil being the pH. The more acid the soil, the greater is the availability; the more alkaline a soil the less is it. In fact on some acid soils the effect of a low pH on crop growth may be such as to cause manganese toxicity. As a result of this investigation lime should not be added to Wait-a-bit Clay soil unless calcium deficiency exists in the bananas or the acidity is making some element toxic to the banana.

(c) **Manganese and speckle (*Deightonella torulosa*):** Mention has been made that where the black scab exists on banana fruit there is usually every gradation in size of spot from the typical 'speckle' to the scabs of varying diameters. Both are now known to be caused by the same fungus (*D. torulosa*) but the black scabs are associated with conditions where the plants suffer from a manganese deficiency. Stahel (1934) describes *Helminthosporium torulosum* (syn *D. torulosa*) as a strong parasite and thus it may be that speckle may be reduced though perhaps not prevented by an optimum level of manganese in the banana plant. Apart from the factors, detailed by Meredith as affecting the incidence and degree of speckling, the availability of manganese in the soil may possibly be operative. Experiments are planned to test this premise. It is worthy of note that the section of St. Catherine plains on which speckle can be very severe contains some of the most alkaline soils growing bananas in Jamaica.

G. First FAO/CCTA International Meeting

A paper entitled "Some Soil Requirements of Lacatan Bananas in Jamaica" was prepared for presentation at the First FAO/CCTA International Meeting on banana production at Abidjan, Ivory Coast.

IV. REPORT OF ANALYST (DOROTHY E. BOLAND)

During 1960, much time was spent on standardizing and refining the existing methods of leaf sample collection. The leaf analysis programme was extended to NPK fertilizer experimental plots which were being concluded, and these analyses were used as a means of determining nutrient response in the leaves to fertilizer applied at varying levels.

A comprehensive study was made of all leaf analysis results, with special reference to ways in which these results could be used to assess the nutritional status of the banana plant.

During the year, 714 samples were received and some 4,750 analyses were done in duplicate. The method for determining Magnesium was changed to a compleximetric method using EDTA, Ashwin & Ritchie (1957). All other methods remained as stated in the Annual Report 1957-1958.

Besides leaf analysis, organic and inorganic fertilisers were analysed.

Towards the end of the year, four compounds were tried as a means of increasing the adhesive properties of **P.E.P.S.** (Vancide 50) when applied to cut stem ends of banana bunches.

A. Leaf Analysis

From previous work, a tentative method for collecting leaf samples was outlined until the details of certain effects could be checked.

The Stage 2 division of the arbitrary developmental growth stages was selected for sampling. This stage covered plants which had just completed the 'sword' leaf stage until $\frac{2}{3}$ grown, i.e., before initiation of flowering. The outer limit of this stage has received much criticism and it is agreed that the description is not very helpful in the field. For purposes of standardization, we have therefore chosen the early Stage 2 plant. In a 'plant' field, this is equivalent to plants approximately 6 months old.

Some mention was made in the last Annual Report of the possible effect of the degree of emergence of the heart leaf on the nutrient composition of the other leaves. The choice of plant was therefore restricted to those with the heart leaves just emerged.

Leaves were collected before wilting occurred and the middle of the lamina (about 2 feet) on the left side of the midrib (viewed from below the leaf tip) was taken. The present description was found to be of more practical value than that previously described in the 1959 Annual Report. The choice of the second fully opened leaf was made in preference to the third leaf since leaf 2 was as good an indicator as leaf 3 at the growth stage being used, and from field observations wilting occurred first in the older leaves so that leaf 2 was usually not wilted, at time of collection.

From analyses done on healthy plants of good productivity in various parts of the island the following values were found to be characteristic of an adequate nutrient status using the second fully opened leaf of a plant 6-8 months old — 2.8-3.0% N, 0.45-0.50% P_2O_5 , 3.80-4.0% K_2O , 0.90-1.1% CaO and 0.60-0.70% MgO. These can be used as a tentative guide for assessing the nutrient status of banana plants.

B. Refinements to Leaf Sampling Technique

Conditions at time of sampling which were likely to influence leaf nutrient composition were investigated. Some of the effects studied were (a) collection of samples at different times during the day and the relation to water supply, (b) the effect of degree of heart leaf emergence on nutrient composition of other leaves and (c) refrigeration of leaf samples before processing.

(i) **Time of sampling (diurnal) and leaf nutrient composition:** The collection of leaf samples is usually done in accordance with regular working hours. The major part of the collection is done in the morning (between 9-11) and in cases where two places are visited, it is sometimes necessary to collect in the afternoon (2-4 p.m.).

The condition of the leaves at these sampling times varies with temperature, humidity and topography. Some variation of nitrogen with water content of leaves was noted in sugar cane and it was suggested that this line of investigation be followed in the banana plant.

Diurnal changes in leaf nutrient composition were followed in a Stage 2 banana plant. Six leaf punches from a banana leaf were collected at hourly intervals from 6 a.m. to 5 p.m. Temperature and humidity measurements were made and the water content of the leaf punches was determined. The dried samples were analysed for nitrogen, phosphate and potash. Unfortunately, the conditions on that day were not ideal. The leaf wilted at about 10 a.m. but opened again when the relative humidity increased and there was a threat of rain. However by noon, the leaf had wilted again and remained so until 3 p.m. when it started opening gradually. By 5 p.m. it was fully expanded (Appendix Anal. 1).

Leaf nitrogen increased when the leaf was fully expanded and exposed to sunlight. Phosphate values were steady throughout the day but showed a slight rise towards late afternoon. Potash was lowered at wilting but was highest when the leaves were expanded and relative humidity high.

This experiment was done only once but acted as a guide to subsequent investigations of wilted and non-wilted leaf samples. A similar pattern of a slightly decreased nitrogen and potash in wilted samples was obtained. A statistical "t" test applied to the results of seven composite samples collected from wilted and non-wilted samples however showed no significant differences between treatments. (Appendix Anal. 2).

(ii) **Stage of heart leaf development and nutrient composition of Leaf 2:** Leaf samples were collected from the second fully opened leaf of Stage 2 plants with heart leaf stages from 0-0.9. There were no significant differences for any of the major elements as affected by developmental stage of the heart leaf.

When collecting leaf samples, it is therefore not necessary to select a plant with the heart leaf at a particular stage of development.

(iii) **Refrigeration of leaf samples:** Certain trends, namely, lowered nitrogen and phosphate in refrigerated leaf samples, have been observed, but this project requires expansion before any conclusion of statistical significance can be drawn.

C. NPK Experiments

These experiments provided a means of checking the sensitivity of the leaf sampling technique which had been established. It was possible to determine in what way leaf nutrient composition varied with controlled application of nutrients and to detect interactions between certain elements. By sampling 'good' and 'poor' areas, it had already been shown that this technique was able to detect differences in nitrogen and potash status of banana fields (Ann. Rep. 1959 p. 12).

The following experiments were available for sampling: (a) Three $3 \times 3 \times 3$ Factorials, (b) One $3 \times 3 \times 3$ Factorial using nematode-free suckers and a higher frequency of fertilizer application and (c) Two $3 \times 2 \times 2$ Factorials. The latter were sampled in 1959 shortly before those experiments were concluded and the others were sampled and analysed in 1960. Statistical analysis was done to compare the variation of major elements in the leaf with that of known fertilizer applications.

(i) **$3 \times 3 \times 3$ Factorials:** Sites I and II were located in St. Mary and were comprised of blocks, on two locations each. Site III was situated in St. Ann. These were the remaining experiments from a batch which had been started to determine the nitrogen, phosphate and potash requirements for bananas on various soil types.

At Site III, there was no significant response of any leaf nutrient to any of the treatments applied and the levels in the control plot must be assumed to have been adequate, the values being 3.08% N, 0.53% P_2O_5 , 4.62% K_2O , 3.02% CaO and 0.42% MgO. Leaf calcium tended to be high in all Blocks of this experiment, understandably so since the pH of the soil was 8.2. On Site I there was a significant difference between leaf calcium in Block I as compared with Blocks II & III, the calcium being higher in Block I. In Block I the pH of the soil was 7.9 while in Blocks II & III it was 6.0. Calcium values in the leaf have therefore given some indication of soil pH.

In the remaining two experiments there was a significant difference between the potash status of the three blocks comprising each experiment. Leaf potash tended to be above 4.0% when the available potash in soil exceeded 200 ppm. At Site I, there was no response to potash when applied singly, but when applied with nitrogen at the intermediate level the response was significant. When leaf phosphate was low potash tended to be high. Leaf calcium was best in plots receiving both nitrogen and potash at the intermediate level. A significant interaction was obtained for leaf magnesium in plots treated with phosphate and potash. (Appendix Anal. 3).

(ii) **$3 \times 3 \times 3$ Factorial with nematode-free suckers:** This was the fertilizer experiment in which these suckers were used. The experiment was in Trelawny, sited on soil with low pH, low available phosphate and medium potash status.

There was a significant increase in leaf nitrogen in nitrogen-treated plots. Leaf potash varied between blocks but showed a significant response to application of potash fertilizer and also to applications of nitrogen. High nitrogen tended to depress leaf potash. Magnesium in the leaf decreased significantly with application of phosphate at the intermediate level. (Appendix Anal. 4).

Values for leaf nutrients in the control plot were: 3.30% N, 0.45% P_2O_5 , 3.77% K_2O , 0.76% CaO and 0.53% MgO. This was the only experiment in which a direct response to a particular nutrient was obtained. Whether this was due to the increased level of fertilizing or to greater uptake of fertilizer by the healthy roots, has not been determined.

(iii) **$3 \times 2 \times 2$ Factorial experiments:** Site I was located in St. Mary and Site II in St. Thomas. Both soils were alkaline, Site I being more so than Site II, available phosphate was low in Site II and medium to high in Site I. Available potash was adequate on Site

I but medium on Site II. Results are presented in Appendix Anal. 5. Leaf analysis showed a significant difference between phosphate, potash, calcium and magnesium on the two sites but there was no direct significant response between leaf nutrients and their corresponding treatments. Nitrogen was very low in Site I and a response to nitrogen was expected, but there was no significant difference between any of the nitrogen treated plots.

When nitrogen was low, addition of phosphate resulted in high leaf phosphate, but further addition of nitrogen depressed leaf phosphate. (A similar finding was previously described for analysis of a low-nitrogen area in the Annual Report 1959, p. 12). Where nitrogen was adequate, increasing nitrogen applications did not have any significant effect on leaf phosphate. Phosphate uptake was best in plots adequately supplied with nitrogen and potash. Leaf calcium was high on both sites and indicated that they were located on alkaline soil.

All results, with the exception of (b), were from experiments established before the advent of the "clean sucker" programme for eliminating the burrowing nematode (*Radopholus similis*).

The leaf sampling technique used has been capable of detecting nitrogen, phosphate and potash responses. Several significant interactions have shown the effects of one nutrient on another. There was also some correlation between available potash in the soil and leaf potash and although there was no direct application of calcium to the soil, leaf analysis indicated the soil reaction.

D. Nutrient Ratios

In addition to the tentative levels of adequacy which have been stated for the major elements, it was considered that nutrient ratios would be a useful adjunct for determining the nutritional status of banana plants. From the NPK experiments, it was evident that nutrient balance was important and a number of ratios for the major elements have been determined. The ratios which give the best indication of nutritional balance are those in which the sum of the percentages of nitrogen, phosphate and potash is termed "T" and the ratios N/T, P_2O_5/T , K_2O/T are calculated. Similarly the sum of the percentages of potash, calcium and magnesium is called "R" and the ratios of K_2O/R , CaO/R , MgO/R are calculated. It was considered necessary to use potash values in both ratios since one of the functions of potash is to act along with sodium, calcium and magnesium to balance organic acids and other inorganic anions such as phosphate, sulphate, and chloride in leaves. Low or high ratios indicate directly whether the particular nutrient is in short supply or not.

Nutrient ratios from fifteen areas of good productivity were calculated and the following values were obtained: N/T, 0.39-0.44; P_2O_5/T , 0.06-0.08; K_2O/T , 0.49-0.55; K_2O/R , 0.66-0.74; CaO/R , 0.18-0.26; MgO/R , 0.09-0.13.

For ad hoc investigations, leaf analysis may be required on plants that are older or younger than the Stage 2 plant. Nutrient ratios were therefore calculated from results available for the four arbitrary stages of growth used in the leaf analysis programme. (Appendix Anal. 6). N/T values were lower in Stage III and 'shot' plants, P_2O_5/T was similar at all stages and K_2O/T was higher in Stage III plants. Since the Stage III plant covers the period preceding emergence of the inflorescence the changes may be associated with the physiological changes occurring at that time.

E. P.E.P.S. (Polyethylene-polysulphide paste)

Four compounds with detergent properties (Teepol, Triton X-114, Sopanax or Orthotolyl-beguanide and Tetra Potassium Pyrophosphate) were combined with P.E.P.S. in an effort to increase its adhesive properties on cut fruit stalks, following a complaint that it was being washed from the stem ends whenever loading of bananas took place in rain. Two concentrations of each mixture were prepared. For the liquid detergents, 1% v/w and 0.1% v/w mixtures were prepared, and for the solid detergents, 1% w/w and 0.1% w/w mixtures were prepared. The mixtures were applied to freshly cut butt and tip stem ends. One set was allowed to dry. The stem ends were subjected to artificial rain for periods of 2 minutes, 4 minutes, 6 minutes. The percentage of P.E.P.S. washed off was assessed by eye. All mixtures adhered best on the butt ends, their behaviour on the tip-ends being extremely variable. The P.E.P.S./Triton mixtures proved to be the most effective paste on the butt and tip-ends of the bunches.

V. REPORT OF AGRONOMIST (V. R. LUMSDEN)

A. Fertilizer Experiments

(i) **NPK trials:** At the beginning of 1960 there were six complete 3^3 and one block of a 3^3 factorial experiment in progress. Two of these were sited in St. James, one in St. Ann, one in St. Thomas and the remainder in St. Mary.

Two new ones were started in 1960 — one in St. James and one in the Christiana area. This latter was planted with nematode-free suckers in an area on which bananas had not been planted for some time.

It is suspected that nematodes have been affecting the results of the fertilizer experiments and it is intended to repeat some of these experiments using nematode-free suckers for planting material.

(a) **St. James:** Both of the experiments in this area suffered severely from the drought periods of 1957 and 1958 and several of the plots failed to recover. These plots did not yield sufficient fruit for a reasonable statistical analysis to be made. The plots which did not recover failed to follow any treatment pattern and their failure to recover could not be considered a treatment effect.

(b) **St. Ann:** This experiment was laid down on soil derived from a coastal limestone. The top soil was fairly shallow. The experiment was planted out in 1958 and during the same year suffered extensively from drought. The effects were particularly noticeable on the eastern end of all three blocks and before the plant crop from these plots was completed the field was destroyed early in 1960 by torrential rainfall which converted it into a water course.

(c) **St. Mary:** The treatments consisted of sulphate of ammonia, single superphosphate and muriate of potash each of three levels, three times a year (Appendix Agr. 1a.). The soil type was Belfield Clay, alkaline in reaction, with a medium to low phosphate status and a medium to high potash status. The area was previously used as a pasture.

This experiment was planted in April 1956 and the results up to December 1960 were analysed. The plots were all affected by the severe drought of 1957 and 1958 and to a lesser extent in 1959. Block III, because of its more exposed aspect, suffered more than the other two blocks and there was therefore a significant difference between blocks in respect to av. no. of hands/stem, av. weight/hand (lbs.) and also total weight of fruit/plot. The N_2 level of nitrogen gave an increase over the N_0 and N_1 levels in respect of nos. shot/plot but this was not significant at the 5% level of probability. Increasing potash tended to give increases in av. no. hands/stem, av. wt/hand (lbs.) and also in total wt. of fruit/plot but these increases were not significant at the 5% level. In all the calculations the P_2 level of phosphate tended to depress yields but they were not significantly lower than the yields obtained at the P_0 or P_1 level.

It must be pointed out that the root systems of plants in Block II and III were heavily infected with eelworm.

(d) **St. Mary:** The treatments for this experiment were the same as for the previous one (Appendix Agr. 1b). The soil type was mainly Water Valley silty clay together with some Belfield Clay, alkaline in reaction with a low phosphate and medium to high potash status.

This experiment was planted in July 1956 and the results up to December 1960 were analysed. As in the previous experiment drought periods in 1957, 1958 and to a lesser extent in 1959 severely affected the plots. There was an outbreak of leaf spot infection in the plots in 1958 and oil-spray was used to control this.

The most important result was the increases obtained by nitrogen. In all the calculations with the exception of av. wt/hand (lbs.) the N_2 level of nitrogen gave significantly higher results than the N_0 level. Increasing potash tended to give increasing yields but these were not significant. Although the interaction between nitrogen and potash was not significant, the best results were obtained when high nitrogen was applied with high potash.

(e) **St. Mary:** Only one block of this experiment came to fruition. The treatments were the same as the other 3^3 NPK experiments. No analysis could be carried out but on observation of the results from the one block it appears that the important fertilizer here is potash. Good increases were obtained with increasing potash with respect to av. no. of

hands/stem and also av. wt/hand (lbs.) (Appendix Agr. 1c). The P₁ level of phosphate has given good increases and appear to be adequate.

(f) **St. Thomas:** This experiment was laid down in May 1956 on a gravelly loam developed from recent alluvium on the banks of the Morant River. The phosphate status was high and the potash medium to low. Extreme dry conditions in 1958 together with the difficulty of obtaining labour led to the neglect of the cultural practices and plots suffered badly.

High nitrogen and high potash gave slight increases in the no. of hands/stem, but these were not significant (Appendix Agr. 1d).

(ii) **Fertilizer & Nemagon:** It has been suggested that the results of the fertilizer experiments were being affected by nematode infestation of the banana roots in the plots. In co-operation with Shell International Chemical Company, two experiments were laid down in which similar fertilizer treatments were applied to plots treated with and without Nemagon.

(a) **St. Catherine Plains:** Three levels of Nemagon in all the combinations with two levels of ammonium sulphate were used (Appendix Agr. 2). This experiment was unfortunately almost completely destroyed by a freak windstorm shortly after the completion of the plant crop and had to be abandoned. Analysis of the plant crop figures showed that there were no significant differences between the Nemagon treatments in respect of the no. of days to shooting or the av. weight/hand (lbs.). The no. of hands/stem was slightly, but significantly increased in the Nemagon treated plots over the untreated plots. There was no significant difference between the N₁ and N₂ levels of Nemagon. There was also no difference between the two fertilizer treatments.

(b) **St. Thomas:** This experiment was laid down using the "ring treatment method" of applying the Nemagon. Unfortunately the experiment had to be abandoned when it was fertilized in error by the labourers on the property.

(iii) **Urea experiments:** The two experiments, laid down on the St. Catherine Plains in an attempt to find an economic level of fertilizing Lacatan bananas in a high population stand, are still in progress. The plant crop is complete and some shooting for the 1st ratoon is now taking place.

B. Cultivation Experiments

(i) **Pruning:** Three of the several pruning experiments initiated by the Crop Physiologist and handed over for continuation are still in progress and should be completed during the following year. The analysis of these figures will then be done and a report made on these experiments en masse.

There were seven plots remaining at the start of 1960 which were being pruned according to the plan described by the Research Department Occasional Bulletin No. 1. Of these only three gave sufficient figures to merit being reported here. One of these was being pruned according to the 12 month schedule and the other two according to the 15 month schedule laid down in the Bulletin.

The unpredictable pattern of sucker production coupled with the spread of several months in the shooting of the plant crop, has led to a breaking down in the degree of control in the pruning schedule called for by the Bulletin. In a high percentage of the plants in the experimentally pruned section an "insurance sucker" has to be left. An "insurance sucker" is any sucker left in a mat where there is no sucker of a desirable size present. The experimental pruning therefore tends to get closer to the estate pruning and this is reflected in the closely related monthly shooting results.

(a) **12 month site — Portland:** This site was planted in June 1958 and commenced shooting in November of the same year. By December 1960, 268.4% of the plants had shot from the experimentally pruned section as against 263.8% from the control. (Appendix Agr. 3a). Examination of the figures show that there is very little or no difference between the control pruning and experimental pruning as to the times when the bulk of the crop comes in. The peaks and the troughs coincide although, on the whole, 10.2% more crop was reaped from the experimentally pruned section in the same period. Nevertheless there was still 9.1% more of the 1st ratoon crop from the estate pruned section falling in the summer months of 1960. The amount reaped during the summer months April '60–Sept.

'60 would have been higher but for winds in October 1959 which blew down 15.3% of plants not shot from the experimentally pruned section and 18.4% from the control pruned section.

(b) **15 month site — Portland:** This site was planted in February 1958 and started shooting in September 1958 (Appendix Agr. 3b). Here again there was fairly close agreement in the figures for the reaping of the bulk of the crop. As in the previous experiment 10.8% more crop was reaped from the experimentally pruned section by December 1960. During the summer of 1960, 6.3% more of the 1st ratoon crop was reaped from the experimentally pruned section but during the winter of 1959/60, 8.4% more crop was reaped from this section. Heavy losses were obtained in these plots from "toppling over" due to nematode and high winds.

(c) **15 month site — St. Mary:** This plot was planted in November 1957 and started shooting in October 1958. By December 1960, 161.0% of the plants had shot from the experimentally pruned section as against 150.6% from the estate pruned section (Appendix Agr. 3c).

At this site 9.1% more crop was reaped from the experimentally pruned section during the "summer" months of 1960. On the whole 8.2% more crop was reaped from the experimentally pruned section up to December 1960.

(ii) **Weeding & forking — Portland:** This experiment is still in progress. There is a very good cover of watergrass in most of the non-weeded and circle-weeded plots. Very good grades have been reaped from these plots. A large number of plants however were blown down by the high winds early in December of 1960.

VI. REPORT OF PLANT PATHOLOGIST (R. LEACH)

A. Blackhead Disease (*Radopholus similis*)

(i) **Disease free planting material:** Two main lines of investigation were undertaken by C. A. Loos, nematologist, during the year, namely seeking for the presence of alternate hosts for the banana burrowing nematode, *R. similis*, and studying its life cycle. He also spent a considerable time demonstrating to growers his method of severely trimming planting material to clean it free of nematodes (Loos & Loos, 1960).

Loos found that *R. similis* appears to be specific to bananas in Jamaica and that it cannot exist in soil free of living banana heads and roots for longer than two months. This enables clean suckers to produce nematode-free banana plants in land freed of nematodes by fallowing or the use of a crop rotation. He suggested that clean suckers should be raised in nurseries in two stages, the first producing 95-98% clean suckers from which a second nursery should be raised containing completely healthy stock.

This method is necessarily a slow one for raising an appreciable amount of disease-free planting material. Many growers wished to forego the use of nurseries and have planted quite extensive acreages of available clean land with heavily trimmed maiden heads, intending subsequently to use suckers from these plants to raise, gradually, cleaner suckers every year until their plantations are practically freed of *R. similis*.

Although no alternate hosts of *R. similis* were found to exist under natural conditions in Jamaica, Loos was able to study the life cycle of this nematode in the roots of a legume, *Tephrosia candida*, under laboratory conditions.

Twelve acres of grassland at Bodles Banana Breeding Station were chosen as a site for the establishment of a clean sucker nursery, this grassland having had no bananas grown on it within memory and being isolated from other bananas by a river which is unlikely to overflow its banks. Approximately 2 acres were established as a Stage I nursery by Loos before he left the Department. W. G. Chambers, Executive Field Officer, assisted him and then took charge of establishing the remaining 10 acres as a Stage 2 nursery when the suckers from the first planting were ready to be dug and cleaned. A "rainer" sprinkler system of under leaf irrigation was installed to provide water, free of nematodes, from a well. This precaution was taken as Loos had found that *R. similis* was present in irrigation water taken from rivers in flood.

Rather than attempt to make a series of similar nurseries throughout the island, the Banana Board, on advice from its Research Committee, decided to establish fifty demonstration plots of *Radopholus*-free bananas with clean suckers from the Bodles nursery. In the meantime instruction was to be given to growers desirous of learning the Loos method

of cleaning suckers prior to planting those portions of their properties known to have been free of banana growth for more than six months. W. G. Chambers was also allocated to this work and is establishing control plots with untreated suckers, alongside each plot planted with cleaned suckers. Both plots are to receive the same cultivation and fertilizer treatments. He is also largely responsible for instructing growers and the officers of various extension services in the methods of cleaning suckers.

During the year several growers showed considerable interest in planting up some of their *Radopholus*-free land with heavily trimmed suckers. Following the advice to fertilize every month from the time of planting, for the first six months, the first growers to plant clean suckers were greatly impressed by the extensive development of the healthy root systems, the sturdy growth made and the absence of any toppling over due to the uprooting of the plants.

A careful check will have to be kept on the rate of reinfestation of fields planted with cleaned suckers on irrigated and non-irrigated land. In the former case special attention will have to be paid to differences relative to the source of water, river versus well.

When the severe and unsightly damage done to banana roots by the burrowing nematode, *R. similis*, has been largely reduced by the use of clean planting material, then the damage done by other nematodes, for instance the root-knot nematode (*Meloidogyne incognita acrita*), will be more easily recognised. As these more ubiquitous nematodes are not as easily eradicated from the soil as *R. similis*, the cleaning of suckers may not ultimately be as successful a means of control as the use of nematocides which may also prove more economical.

(ii) **Soil fumigation:** In view of the successful experiments carried out in West Africa (Vilardebo 1959) with soil injections of Nemagon (1, 2 dibromo-3-chloropropane) an extensive series of experiments was started in 1959, the results of which have been examined and analysed in the year under review. The Department carried out experiments separately and in collaboration with Messrs. Shell International Chemical Company, the latter having sent Mr. M. O. Lane out to Jamaica for this specific purpose, while Dr. C. W. McBeth initiated one irrigation experiment during a visit to the island earlier in the same year.

All these experiments constituted a series of trials designed with the object of testing different methods of applying Nemagon to soil in both irrigated and non-irrigated banana plantations for the control of the nematode diseases of bananas, notably that caused by the burrowing nematode, *R. similis*. The results of these experiments are not described here in detail but appear in the Appendix Path. Tables where all the various treatments are listed and their effects are analysed. The reference numbers of these Tables are mentioned in the following summary of purposes for which the experiments were undertaken.

(a) The addition of Nemagon, by means of a constant flow apparatus, used for flood irrigation (Path. 7, 12) and pipeline irrigation (Path. 5).

(b) The overall injection of land with Nemagon on irrigated land (Path. 8) and non-irrigated land (Path. 9, 11).

(c) The injection of soil around individual plants on irrigated land (Path. 2, 6) and non-irrigated land. (Path. 1, 10).

(d) The injection of soil with DD (Path. 3) close around the mats of an old ratoon field of bananas just about to be cleared for replanting, followed by injection round the young suckers of the plant crop with Nemagon, the DD being used to reduce the population of nematodes remaining in the soil as the land was cleared within a month of replanting. The plants of the second crop were planted in practically the same position as those of the preceding crop, i.e., at 12' x 12' double suckers.

(e) An island wide series of injection experiments, carried out on 33 different estates, to test the effect of Nemagon used on various soil types and at various altitudes. (Path. 4).

The beneficial effects of the Nemagon treatments were much smaller in these experiments than in those carried out by Vilardebo. In only one case did the plant crop benefit and that was where a treatment had been applied at the time of planting in 1958. The first ratoon crops in general showed improvement as regards growth and yields. The increases obtained, in the region of 5-10%, were however insufficient to warrant the cost of the Nemagon, quite apart from the cost of application which is heavy in the case of soil injections.

The Nemagon apparently is not as effective in Jamaican soils as in those of West Africa. The reason for this is at present unknown.

It was significant that wherever Nemagon was injected in rings round the base of plants, one ring of four injections gave as good results as two rings totalling 12 injections. This

would seem to indicate that control is mostly achieved by reducing infection of roots as they emerge into the soil through the cortex of the rhizome.

In two of the experiments (Path. 1, 2, 3) the dosage of Nemagon was inadvertently much higher in the first application than that recommended, due to the emulsion used for each injection being made too strong. This did not adversely affect the growth of well grown plants but young plants showed some characteristic symptoms of phytotoxicity, namely, sheath splitting at the base of the pseudostems, excessive narrowing of the leaf lamina accompanied in severe cases with wrinkling and, in a few cases, die back of the heart leaf. Even such heavy applications of Nemagon were incapable of controlling *Radopholus* satisfactorily in the treated soils.

The records of the all island trial indicated that the Nemagon treatment had given spectacular results in some cases. A statistical analysis, however, showed that, although the treatments were randomized on each property, the untreated plots were by chance more frequently situated on the less fertile parts of the field in which the trial was conducted. If the Nemagon had been effective the treated plots should have shown a gradual improvement over the untreated plots in regard to growth, yield and reduction in loss of plants through uprooting. There was in fact no significant interaction between time and treatment and this fact is well illustrated in Appendix Path. 4b.

Although the island wide trials showed no beneficial effects of the Nemagon injections, the recorded data have provided valuable information regarding the behaviour of banana crops throughout Jamaica because the plots were sited on land typical of the majority of properties growing bananas in Jamaica. The most striking features brought out by the trials were the great variation in yields obtained due to differences in soil fertility and losses of plants through blow downs and the cutting back of bananas suffering severely from drought. Some of the plant crops in St. Mary took 2 years to shoot their bunches, at an altitude of approximately only 500 ft. above sea level owing to being subjected to two severe droughts in the periods June-Oct., 1959 and 1960. These records demonstrate clearly the difficulty encountered in conducting banana experiments where soil fertility and climatic conditions vary as greatly as they do in Jamaica. The plots scattered all over the island on several different soil types have been used by the Soil Chemist and Analyst in their respective research projects.

B. Latex Stain

A peculiar complaint received from the Banana Board's marketing agents in the United Kingdom is "latex stain". Latex, in this sense, is a mixture of true latex and sap which is oxidized to a dark brown colour on exposure to air, being best known perhaps as indelible stain on clothing. When latex gets onto the skin of banana fingers it can stain them badly.

There are two main sources of latex, one from the cut stalks of all harvested fruit irrespective of variety and the other from the bases of the broken styles which persist on the ends of fingers of some banana varieties up to the time that the fruit is harvested. Styles soon become detached and fall off the young fingers of Gros Michel bananas but they are characteristically persistent on those of Cavendish bananas, including the Lacatan and Robusta varieties now grown almost exclusively in Jamaica.

When fresh latex comes in contact with the inner surface of polythene bags used for protecting the fruit, especially where moisture has condensed, it moves downwards by gravity smearing the skin of fingers in contact with the bags. This can result in the fruit being badly stained. Latex stain has only become serious since bananas have been wrapped in polythene to minimise abrasions which result in the development of anthracnose. Previously the fruit was transported to the wharves in leaf trash which absorbed the latex to a great extent. Dried latex is very difficult to remove from fingers unless it is thick enough to flake off the skin.

Dry or even tacky latex does not mix with water so that bananas are likely to suffer less from latex from cut stalks if the latex is given time to dry before the fruit is bagged. Latex from cut stalks tends to collect more on fruit placed vertically in the field stands (collecting booths) than on fruit stacked horizontally.

Latex can flow freely from the base of the styles left on the fingers many hours after the fruit has been harvested. Fresh latex can therefore be released inside bagged fruit at every stage of handling from field to ship. As a result this source of latex flow is often more serious than that from cut bunch stalks.

The possibility that latex flow from broken styles might vary at different times of the day was examined by noting the rate at which drops of latex fall from individual fingers held in a horizontal position both in unripened and harvested fruit.

(i) **Latex flow on bananas hanging in the field:** After preliminary tests bunches of fruit were used in a replicated trial in which they were randomized according to age. The styles were broken off three fingers of each bunch, first starting at 7.15 a.m. and secondly starting at 11.10 a.m. The time taken for the drops of latex to fall from each finger was recorded in seconds. Altogether 30 bunches were treated in this way, the randomization consisting of six blocks of five different aged bunches. The results showed a significant difference between the flow of latex from styles both as regards age of bunch and time of day when broken, the latex flowing slower in the middle of the day, probably due to the diurnal variations in the atmospheric relative humidity affecting turgor pressure. Latex flowed slowest from the youngest fingers (Appendix Path. 13).

(ii) **Latex flow from harvested fruit:** Fruit reaped and stacked horizontally at a field stand was also tested for latex flow. Styles were broken on three fingers of twelve different bunches chosen at random, six between 8.00 and 8.45 a.m. and another six between 11.30 a.m. and 12.15 p.m. There was a significant difference between the rate of latex flow at the different times of day, being faster in the earlier hours, some fingers at that time giving rise to six drops of latex within three minutes (Appendix Path. 14). The rate of flow varied between bunches more in the middle of the day than earlier on.

These tests demonstrate a possible explanation for the variable complaints received regarding the amount of latex stain occurring on fruit shipped overseas at different seasons of the year, the flow of latex from broken styles being considerably affected by variable turgor pressures at different times of the year and in different localities, depending on soil moisture conditions and the relative humidity of the atmosphere. The styles themselves are possibly more brittle at different times of the year.

The need for careful handling is once more made clear by these tests because each time that the fruit is handled styles can be broken and can give rise to increasing amounts of latex inside the polythene bags.

C. Jassid (*Metascarta histrio* var. *sanguinipes*)

A series of small, localized outbreaks of a jassid infestation of banana leaves and fruits occurred in the Parish of St. Mary, during the drought at the end of August and in September. These outbreaks varied in extent from $\frac{1}{4}$ acre to 2-3 acres.

D. W. Mollison, Entomologist of the Plant Protection Division, Ministry of Agriculture and Lands, and his assistant, J. R. Suah, kindly inspected the affected areas and identified the insect. They found that the jassid was feeding on a large variety of plants in the weed flora. It had apparently bred to such large proportions that when the weeds dried up in the dry weather, especially where they were cuttased, it migrated onto the bananas. There it was seen mostly on young followers, notably water suckers, but in a number of cases it had invaded the bunches. Being present in considerable numbers and being dark in colour it was conspicuous on the green fingers. Its presence caused concern because, as the result of its feeding on the skin, the fruit became covered with a thick, white adherent deposit which could not be easily removed by washing in water.

The white deposit originated as minute fountains of sap which could be seen against the sun with the naked eye, spurting out from the skin of the banana fingers, where the jassid had been feeding in such quantities that much of it actually dripped off the fruit. The actual tissue sucked by the jassid was not determined but it would seem to have included the vascular system as only this is likely to have given rise to the quantities of colourless sap which formed the white deposit, banana sap exuding from wounds normally turning brown quickly as the result of oxidation of the latex.

Small localized infestations were successfully eliminated experimentally by mechanical mist-spraying with D.D.T. Should the infestations ever reach more serious proportions this method of control might well prove practicable, though somewhat expensive.

The Plant Protection Division started to investigate the life cycle of the jassid but very soon after the drought was broken the insect returned to its natural habitat, the weeds, where it became widely dispersed and appeared to decrease in numbers.

D. Leaf Spot (*Mycosphaerella musicola*)

Two experiments were conducted to test whether the addition of formulated fungicides to banana spray oil improved its ability to control leaf spot. In one experiment 1 lb. of Blitane (Copper oxychloride/Zineb) was added to every 1½ l.g. of oil applied per acre, this mixture being tested against oil alone applied at the same rate per acre; the treatments

were duplicated and the plot size was approximately one acre. In the other experiment 200 grams of Zineb were added to 1½ l.g. of oil applied per acre, Brunokop (Copper oxychloride in oil) was mixed at the rate of 1 part in 25 at the same rate per acre. The treatments were replicated three times and the plot size was a little under one acre.

In neither experiment did the addition of fungicide improve control. In the first, the mean percentage leaf spot for the nine youngest leaves was:— Blitane + oil 4.2% and oil alone 3.7%. In the second experiment control broke down due to inadequate applications of spray at a critical time of the year, i.e., under conditions where the addition of a fungicide to the oil could have been expected to prove beneficial. The following figures show that this was not so, the percentage leaf spot for eight leaves being:— Brunokop 17.7%, Zineb 15.9% and oil alone 15.1%. In both experiments the Copper oxychloride caused a purple discoloration of the foliage.

E. *Cordana musae*

The fungus, *C. musae*, is usually considered to be only a weak parasite of banana foliage, commonly causing wide, grey areas surrounding leaf spots (*M. musicola*) on the older living leaves. It is not thought to do much harm under such conditions although it can greatly exaggerate the symptoms of leaf spot (Leach, 1959). *Cordana* is seldom seen on the younger leaves of banana plants. Towards the end of 1960 it invaded the torn edges of quite young leaves shredded by unusually high winds in the wet season, in two plantations which shortly afterwards exhibited the symptoms of severe Premature Yellows. The combination of symptoms caused grave concern to the growers affected because they thought them to be those of a breakdown in leaf spot control. This was understandable because *Cordana* had killed considerable areas of the uppermost, torn leaves which were intermixed with the dead, upright lower leaves killed by the deficiency of potash, thus resembling "tip spotting" symptoms of leaf spot. The disease cleared up of its own accord in the absence of further wind damage and the onset of drier weather. Incidentally *Cordana* is clearly a fungus that is unaffected by spray oil.

VII. REPORT OF ASSISTANT PLANT PATHOLOGIST (D. S. MEREDITH)

A. 'Speckling' ('Swamp-spot', 'Fruit-spot')

For most of this year, laboratory and field studies have been carried out in an attempt to discover the cause of this disease and to formulate methods of control. A detailed account of the results has been given elsewhere (Meredith, 1960 a-c, 1961 a-h) and it is proposed here to outline the most important conclusions that were drawn.

(i) **Cause of disease:** Using standard mycological techniques it was possible to isolate the fungus *Deightoniella torulosa* (Syd.) Ellis from a large number of typical speckles. The most important precaution to be observed was not to use too drastic methods for surface-sterilizing fruit before excising tissues for transfer to agar plates. The fungus grows well on potato-dextrose agar and, within two weeks storage at 78-82°F., produces abundant conidia. Speckle was induced artificially on bananas in the field and in the laboratory by spraying with a suspension of conidia in water. Immediately after inoculation, plastic bags were placed on the fingers to ensure high humidity. Under these conditions, typical speckle symptoms appeared within 3 days. It was possible to re-isolate the fungus from these speckles, and it was concluded that *D. torulosa* is the casual organism.

The process of infection was studied. In a film of water on the fruit surface, conidia of *D. torulosa* germinate in 1-2 hr. After 12 hr. one or both of the two germ-tubes normally produced have started to form large terminal appressoria. The appressorium appears to be firmly attached to the epidermis and, after a further 8 hr., may have produced a fine infection hypha which mechanically penetrates the cuticle and epidermal wall. Further penetration occurs through cell walls, intercellular hyphae being uncommon. Soon after the first epidermal cell has been penetrated, its contents are discoloured reddish-brown and there is a darkening of the walls. Surrounding cells subsequently become similarly discoloured resulting in a microscopically visible spot.

(ii) **Factors affecting disease incidence.** Some factors affecting germination of conidia of *D. torulosa* have been studied. In tap water on glass or on the surface of banana fruits, approximately 50% germination occurs after 1 hr. incubation at 28-30°C. After 4-6 hr., nearly 90% of conidia have germinated. Germination does not occur below 98% R.H.: percentage germination in a water film is markedly higher than that at 100%

R.H. Using a series of citrate-phosphate buffer solutions, the optimum pH for germination and germ-tube elongation is in the acid range of 4-6. Substances present in water extracts of banana leaves and fruit peel stimulate germination. This is also true for drops of distilled water that have remained on the surface of young banana fruits for 24 hr. Solutions of several compounds present in synthetic nutrient media provide better germination than distilled water: some carbohydrates tested are particularly favourable.

The longevity of *D. torulosa* conidia is dependent on external humidity. Viability is lost within 3-4 days at a R.H. of less than 95%. At 98% R.H. a small number of conidia may be viable after 10 days storage.

The evidence suggests that the presence of a film of dew or rain water is essential for successful infection by *D. torulosa*. Dry spore films were set up on the peel of detached, 10-day-old fingers which were maintained at constant humidities inside small desiccators containing various saturated salt solutions or water. On other fruit spores were placed on the peel in tap water droplets. The numbers of spots developed after 5 days incubation at 28-30°C. were recorded. It was found that there was a high incidence of spotting on fruit with water film and on that maintained at 100% R.H. A few isolated spots developed at 98% R.H. but none were observed below 95% R.H.

It is well known to growers that severe outbreaks of fruit-spot commonly follow upon periods of heavy rainfall. One series of observations was particularly striking. A plot of bananas had been kept under constant observation from the time when the first bunches had 'shot'. Up till the beginning of the first week of June, 1960, there was little rain and the incidence of spotting was correspondingly low. The plot was re-visited after 7 days of almost continuous rainfall (17.9 in.). The contrast was remarkable, for the intensity of spotting on most bunches examined had increased to a level higher than that in any other instance previously observed by the author. On 15-20-day-old bunches, spotting was restricted to the horizontally orientated inner sides of the fingers. This may be related to the tendency for conidia to impact chiefly on these sides and to the fact that water droplets are retained there for some time. On older bunches, water collects on the inner sides towards the finger-stalk, thus helping to explain the more intense spotting commonly observed in this region.

Experimental inoculations have shown that resistance to infection increases to some extent as the fruit matures. The severity of fruit-spot undergoes seasonal variation, being highest after the rainy periods during April-May and September-October.

(iii) **The dispersal of *D. torulosa*:** The air in two Jamaican banana plantations (A and B) was sampled during the period 19 July-5 October, 1960, at 3 m. above ground with a Hirst automatic volumetric spore trap (Meredith, 1961 f). Each day's slide was scanned and conidia of *D. torulosa* were counted at positions representing 2-hourly intervals. In both plantations there was a clearly defined diurnal periodicity, the peak concentration of spores/m³. of air normally occurring near 08.00 hr. and then decreasing to a low level between 12.00 and 24.00 hr. each day. The period of most rapid liberation (06.00-10.00 hr.) corresponds with that of rapidly increasing temperature and decreasing R.H. This is probably due to a previously undescribed active discharge mechanism operating under conditions of decreasing vapour pressure.

In plantation A, which was surface irrigated, daily mean concentration varied between 0 and 58 spores/m³. when the previous 2-12 days were rainless. After 0.55 and 2.55 in. of rain, concentrations of 377 and 536 spores/m³., respectively, were recorded: the highest 2-hourly estimate recorded was 5280 spores/m³. In plantation B, where under-tree irrigation was practised, successive irrigation periods (each of 48 hr. duration) were associated with considerable increases in spore concentration: rainfall resulted in similar large increases. The highest daily mean concentration recorded was 7115 spores/m³. while the highest 2-hourly estimate was 72,335 spores/m³. at 08.00 hr. on 8 September — approximately 12 hr. after cessation of irrigation. As the plantation dried out after irrigation or rainfall, spore concentration decreased rapidly within 2-3 days.

Both rainfall and irrigation water spray resulted in heavy sporulation of *D. torulosa* on banana-leaf 'trash'; this helps to explain the increased atmospheric spore concentrations referred to above. There was a marked increase in the incidence of fruit-spot during under-tree irrigation periods and when rainfall caused the plantation R.H. to remain high for more than 12 hr. during the day. The incidence of fruit-spot in plantation B was higher than in A; this was related partly to the greater numbers of dead banana leaves, and

hence of spores of *D. torulosa*, in the former, and partly to the favourable effects of under-tree irrigation on sporulation, spore germination and infection.

Considerable reduction in spore concentration occurred after the removal from the plantation of decaying leaves and other banana 'trash', such tissues being the major source of inoculum of *D. torulosa*. Similarly, spore counts in trash-free plantations were consistently lower than those in 'dirty' ones. Although the evidence is not conclusive, since it was not possible to provide controls, it seems likely that good plantation hygiene is able to reduce the air spore content of this fungus.

(iv) **Spore projection in *D. torulosa*:** When a mature conidiophore, with its attached terminal conidium, is transferred from a saturated atmosphere to a drier one, water evaporates from the interior of the terminal cell. The volume of the cell tends to be reduced, but this reduction is resisted by the rigidity of the cell wall. However a stage is reached when the negative pressure inside the cell causes the thin area of the wall at the apex to be pulled inwards: the thicker regions of the wall are not visibly distorted. As the top of the conidiophore caves in, so the conidium is retracted in much the same way as a missile being loaded in a catapult. This 'loading' continues as further evaporation takes place. The state of tension in the aqueous contents of the cell increases until a point is reached when rupture occurs and a gas phase suddenly appears: the evidence suggests that the gas phase is water vapour. The appearance of a gas phase releases the inward pull on the caved-in wall, which springs outwards and rounds off. Whether it is (1) the elasticity of the recoiling thin wall or (2), the rounding-off process, which is responsible for projection is not known. This appears to be the first record (Meredith, 1961 d) of a gas phase being associated with violent spore discharge in a fungus.

(v) **Control measures:** A method of controlling speckle is suggested by the fact that the causal fungus is common on dead or dying banana leaves, either hanging from the pseudostem or lying on the ground. Chopped-up pseudostems are also a source of infection. Any form of banana trash may be suspected of harbouring the fungus. Several growers have remarked upon the fact that removal of trash before heavy rains resulted in considerable reduction in severity of fruit-spot: weed removal was also beneficial. Uncleared plantations downwind of clean ones showed a high incidence of spotting. Arrangements have now been made to test the effect of detashing and plantation hygiene on the incidence of fruit-spot. It is of importance to assess for each area the amount of extra labour costs and to compare them with expenses involved in using possible alternative control measures such as fungicidal treatment or bunch-protecting plastic bags.

B. An unusual fruit-spot caused by *D. torulosa*

Several instances of a severe and unusual form of spotting have been observed (Meredith, 1961 b). One plantation in the Christiana district was particularly noteworthy, but isolated cases were also found on the lowland plains of St. Catherine. The largest spots observed were approximately 6 mm. in diameter, raised in a convex fashion and dark-brown or black in colour: they are best described as being scab-like. Similar smaller spots, 1-3 mm. in diameter, usually had a water-soaked halo and closely resembled typical speckle. On most affected fingers, there was a continuous series of spots ranging from typical speckle to the large, scab-like spots. On fruit up to 25 days old, spotting was restricted to the inner sides of the fingers. On older fruit, the outer sides were often affected also, but to a lesser extent.

On isolation plates inoculated with pieces of scab tissue, *D. torulosa* appeared in a high percentage of cases. An attempt was made to induce the development of these spots by experimental inoculation with *D. torulosa*. Apparently healthy 10-day-old fruit was collected from the Christiana plot and, after washing, was sprayed with a dense suspension of conidia. Many small 'speckles' developed after 48 hr. incubation at 28-30°C. After 5-7 days, some of these spots had developed into characteristic scab-like lesions.

These observations suggest that *D. torulosa* is the cause of scab-like spots which develop under natural conditions. It may be that the physiological condition of fruit peel tissues affects symptom expression. The possibility that peculiar soil conditions are indirectly responsible for this is to be investigated.

C. Other Diseases Caused by *D. torulosa*

(i) **Black-spot of leaves:** A 'black-spot' disease of leaves of 'Gros Michel' bananas in Jamaica was first described by Ashby (1913) and the causal fungus was given the

name *Cercospora musarum* (syn. *D. torulosa*). An early stage of disease is indicated by pin-point black spots on the main veins near the margin of the lamina. Each spot increases in size, eventually becoming lenticular and surrounded by a bright yellow border. Further increase in size occurs in a fan-like fashion towards the edge of the lamina. Individual spots may unite and give rise to a broad zone of pale-brown, dry tissue around the periphery of the lamina. The studies of Stahel (1934) provided convincing proof of the pathogenicity of *D. torulosa* and the author (see above) found that the details of germination and penetration of banana fruit, leading to the development of fruit-spot, are closely similar to those on leaves, as described by Stahel.

'Black-spot' can be observed on 'Lacatan' bananas in most Jamaican plantations but with the exception of isolated plots at Christiana and elsewhere, it is not of great economic importance (Meredith, 1961 b).

Inoculation experiments were designed to test the ability of isolates of *D. torulosa*, obtained from fruit-spots, to infect banana leaves. The results showed that isolates of *D. torulosa* which cause fruit-spot may, under favourable conditions, also cause 'black-spot' of leaves. Similarly, it was found that 'black-spot' isolates infected banana fruits and caused typical speckling.

(ii) **Black-tip of fruits:** In Bermuda, Ogilvie (1928) described a disease ('black-tip') of 'Cavendish' banana fruits caused by *D. torulosa*. The disease is characterized by a black discolouration of the skin at the finger-tip. This blackening is usually on one side of the fruit only and is bordered by a narrow grey or light-yellow margin. The complete finger is seldom affected and ripening appears to inhibit further development of the disease: mycelium of *D. torulosa* may develop on the surface of the diseased tissues. The fungus is localized in the outer peel tissues, the amount of internal decay produced being negligible. Wardlaw (1932) observed isolated cases of disease on 'Cavendish' and 'Lacatan' bananas in Trinidad. He considered that infection originates in the perianth or style and, that the penetration of hyphae into the fruit takes place as a result of delayed or incomplete formation of the corky layer which normally seals the end of the fruit after decay of the floral parts. A direct connection between hyphae in the base of the style and those in the tissues of the fruit skin was observed.

'Black-tip' is uncommon in Jamaica and so far in these investigations only a few examples have been found. In every case, fruit affected by this disease was also heavily spotted. The plot at Christiana was of particular interest in that there was severe fruit-spot, 'black-tip' and 'black-spot', all caused by *D. torulosa*.

Inoculations (Meredith, 1961 b) were designed to induce 'black-tip' experimentally. A young bunch of 'Lacatan' bananas (approximately 15 days from the time of 'shooting') was sprayed with a dense suspension of conidia of *D. torulosa* until run-off occurred. Conidia were obtained from the same culture that was used for leaf-inoculation. The bunch was then covered with a plastic bag which was sealed at both ends. After 7 days it was found that the fruit was very severely spotted and two adjacent fingers on the large proximal hand displayed characteristic 'black-tip' symptoms. Many similar inoculations have been carried out during the course of the year, chiefly with the object of inducing fruit-spot. In many instances, 'black-tip' developed on heavily spotted fingers but none on those that were only slightly spotted.

In other inoculations, a small incision was made in the corky tissue at the tip of the fingers: conidia were applied to the wound. In all instances typical 'black-tip' symptoms developed after 7 days incubation at 28-30°C. in a saturated atmosphere.

These experiments demonstrate that isolates of *D. torulosa* from fruit-spot are able to cause 'black-tip'. The converse is also true, for isolates of *D. Torulosa* obtained from naturally occurring 'black-tip' infections caused typical fruit-spots after inoculation.

D. 'Cigar-end' Type of Infection

An outbreak of 'black-tip' disease, caused by *D. torulosa*, in a plantation of 'Lacatan' bananas was found in 1960 on the St. Catherine plain. Disease was particularly severe where drainage was poor and atmospheric humidity high. Symptoms were more advanced than any recorded previously in Jamaica. In a few specimens, there was extensive dry rotting of the inner pulp, from which *Verticillium theobromae* was isolated. *D. torulosa* was isolated from necrosed peel but not from decayed pulp. External symptoms included those of both 'black-tip' and 'cigar-end' diseases. The evidence suggests that this type of tip-rot is a result of primary infection by *D. torulosa*, followed later by *V. theobromae*.

E. Commercial Trials on Control of Anthracnose and S.M.S.E.R.

In several commercial-scale experiments bunches of bananas were treated by immersing for approximately 1 min. in 2% Shirilan WS and then rinsing in water. Reports obtained after ocean transportation and subsequent ripening of fruit in England indicated that this treatment effected poor or no control of fruit-rot (anthracnose and Santa Marta stem-end rot) caused by *Gloeosporium musarum* Cke. & Massee (Meredith, 1961 h). Thus, the expectations of earlier laboratory work (Meredith, 1960 b, d, e) were not realized under commercial conditions.

It is hoped to intensify the search for a suitable chemical with which to control fruit-rot, for there is little doubt that wastage from this source is at present of major importance to the industry.

F. Discussion and Suggestions for Future Research

Although much has been discovered about the epidemiology of speckle, which at times causes some concern to the industry in Jamaica and other Central American countries (Meredith, 1961 g), it is clear that its control presents difficulties. Plantation hygiene may be successful but it is not easy to carry out economically. Further, the removal from the plantation of large quantities of banana debris is often objected to on the ground that valuable organic material is lost to the plantation. It will be necessary to test the possibility of controlling disease by fungicidal and other means.

Little progress has been made in controlling fruit-rot due to *G. musarum* and other fungi. However, even the best chemicals may not be effective if fruit is badly damaged mechanically. Future research will involve not only the chemical approach, but also an investigation into ways of improving bunch protection during transportation and storage.

VIII. REPORT OF PLANT BREEDER (R. E. OSBORNE)

Breeding research, which was hitherto divided between Jamaica and Trinidad, was handed over to the Research Department by the Ministry of Agriculture and Lands, Jamaica, on April 1, 1960 with the approval of C.D. & W. Scheme R1147 and Mr. R. E. Osborne joined the Division as Plant Breeder. The transfer from Trinidad was completed on September 26, 1960 when Mr. K. Shepherd arrived to join the Division as Cytogeneticist. Field operations have been carried out at Bodles and Rhymesbury; Mr. R. A. Gonsalves is the Senior Station Officer in charge of both Stations. Other field projects are maintained at Caenwood and Orange River, which are Stations operated by the Ministry of Agriculture and Lands, as well as on land belonging to banana growers throughout the island.

A. Administration

(i) **Staff:** Miss A. Hilton was transferred to Head Office; Miss Y. Henry and Mr. H. Anderson were employed at Bodles as Stenographer/Typist and Junior Assistant respectively.

Mr. R. A. Gonsalves was on three months vacation leave from May 12 to August 10, 1960.

(ii) **Buildings:** At Bodles the usual maintenance of office buildings and residences was completed; extensive repairs were made to the original greenhouse; the implements shed was extended and the lunch room together with sanitary conveniences for workers were improved.

At Rhymesbury a new prefabricated aluminum house was erected bringing the total to five. Store-room facilities were enlarged and workers' amenities improved.

(iii) Among the numerous visitors to the Stations were Drs. F. C. Steward, Mohan Ram and W. G. Barker of Cornell University; Mr. A. F. MacKenzie, Federal Agricultural Adviser; Mr. D. A. Perryman, General Manager of Winban.

(iv) The Plant Breeder was appointed Secretary of the Scientific Advisory Committee on Banana Breeding Research, and attended the first meeting of the Committee at the Imperial College of Tropical Agriculture, Trinidad, on May 29, 1960.

B. Pollination

Gros Michel and Highgate were the only female parents grown at Rhymesbury for the production of tetraploids. The observance of strict quarantine measures combined with the use of a sprinkler irrigation system seem to have retarded the spread of Panama Disease.

Frequent heavy winds have resulted in the loss of 206 bunches of which 18 were Highgate; losses were minimized by extensive propping.

Details of pollinations together with the yield of seed are given in Appendix P.B.1.

C. Greenhouse

Details of seed planted, germinations and seedlings obtained are given in Appendix P.B. 2. Elsewhere, under the Cytogeneticist's report is given an interim account of the germination behaviour of tetraploid seed, from Gros Michel crosses, in relation to seasonal variation.

D. Nursery

There were 205 tetraploids planted out during the year of which 29 were of the Highgate cross. After selections were made, a total of 169 tetraploids remained in the field. Details are given in Appendix P.B. 3.

E. Panama Disease Testing

All testing for resistance to Panama disease was done in the field and the duration for each clone was fifteen to eighteen months. During the year 23 new clones were planted out for testing; there are now 17 clones remaining in the field. Details of the crosses are given in Appendix P.B. 4.

An unusual behaviour of tetraploids, which have passed through the Panama Disease Testing Stage, had arisen in two fields (V and VIII) at Bodles. One tetraploid 10648-1 had 23 diseased mats out of a total of 30 when the plants were 8 months old. Ten good suckers were then removed, thoroughly cleaned and washed and planted in a different field (III). The plants are now 9 months old and are growing vigorously with no signs of Panama disease. Another tetraploid, 1847, was planted in field V where 500 mats were growing in a nursery and there were 64 mats with Panama disease. This clone is growing at several different areas in the island without a case of Panama disease.

It appears that conditions in Fields V and VIII are more conducive to infection with Panama disease than elsewhere; the condition is being watched.

F. Observation Plots

(i) **Thirty root:** One tetraploid had successfully passed the Panama disease test and was planted in the 30-root observation plot at Caenwood and Bodles. There were 26 tetraploids in plots at Bodles, Caenwood and Orange River. Fruit of the ratoon crops will be observed early in 1961 and selection made of the more promising clones for extended field trials.

(ii) **Windward Islands:** With the introduction of the Windward Islands into the Breeding Research Scheme, 30-root observation plots have been established in each of the four banana producing islands. Clones 1847, 2390-2, 8179-2, 10137-1, 10304-8, and 10648-1 have been planted at three sites in each island. Maintenance and supervision of the plots will be the responsibility of the local Departments of Agriculture.

(iii) **Cameroons:** Clones were also grown in the Cameroons and the following have now been sent — 1877, 1847, 2390-2. Suckers of 8987 and 8179-2 are at Kew being quarantined before transhipment to the Cameroons.

G. Extended Observation Plots

There were three clones in extended observation plots — 8987, 8179-2 and 2390-2. Of these, 8987 was the least promising and was not considered worthy of further testing. Clones 8179-2 and 2390-2 will be multiplied for observation of fruit.

H. Half-Acre Observation Plots

Clone 1847 has now been established in twelve commercial observation plots throughout the country; the sites were chosen to be typical of the banana growing areas. Growth has been satisfactory and fruiting has just commenced. A small plot of 20 plants was established in an area at Holland, St. Thomas, to observe the behaviour of the clone under conditions conducive to premature yellowing. There was some yellowing just before the plants flowered, but the degree of the disorder was much lower than adjacent Lacatan plants which were severely affected.

I. Suckering Comparison

Field records of suckering comparison trials with 1847 and Lacatan have been completed at Bodles, Caenwood and Orange River. Analysis of the records have not yet been finalized.

IX. REPORT OF CYTOGENETICIST (K. SHEPHERD)

A. Diploids

(i) **Seedlings in Trinidad** — examination of these was of necessity completed during the year.

In some families from Samoa crosses, it seemed possible to discriminate clearly between plants resistant or susceptible to Sigatoka with very few doubtful cases. Generally about half the plants were resistant to highly resistant, suggesting the segregation of a major gene. Many selections from these families were shipped to Jamaica.

Other crosses produced seedlings with more or less vertical bunches with varying grades and finger size, and of these ten selections were made.

(ii) **Seedlings at Bodles:** Virtually all of these were derived from pollinations in Trinidad. Some Samoa crosses produced families from which very promising selections were made, having good grades and high resistance to Sigatoka. Unfortunately, two with exceptionally good grade were susceptible to Panama disease.

Other crosses yielded families which were inferior to Samoa crosses and had little breeding power.

(iii) **Current programme:** Pollinations in Trinidad ceased in January 1960 and, with few potential parents flowering in Jamaica, little has been attempted. Extended plantings of clones which might contribute, particularly as female parents, in the next phase of crossing, were done at Bodles and are now shooting. Meanwhile, three different pollen sources have been used on the large Tongat planting.

A greatly increased and more complex pollination programme was planned and it was decided to separate diploid and other Bodles pollinations from the annual number sequences used for Gros Michel and Highgate crosses. A system based on the Trinidad one was begun in March with a sequence of pollination numbers not renewed annually and serving also to identify progenies in the field and selections from these if any. Crosses in the diploid breeding programme will bear also the initial letter 'A' to distinguish them from number series for other types of pollination. It is hoped that a clip-card recording system, to be initiated in 1961, will greatly facilitate the isolation and collection of data on each cross.

B. Seed Production at Rhymesbury and Bodles

The first two years of pollinations at Rhymesbury from the end of June 1958 to the 30th June, 1960 yielded 3,426 seeds from 7,183 Gros Michel bunches reaped, an average of a little under half of a seed per bunch. The two years were consistent, although different areas were in use: 2720 bunches gave 1380 seeds in 1958-59, 4463 bunches gave 2046 seeds in 1959-60. Inasmuch as the poorest Bodles fields averaged in the neighbourhood of one seed per bunch and the best, field 8, averaged 2.69 seeds (Shepherd 1960), it would seem at first sight that Rhymesbury was a much inferior site. If this was a fact, it would greatly add to the difficulties; the results were therefore submitted to more detailed scrutiny in search of any mitigating factor or factors. This analysis came chiefly under two heads; first, a comparison of Bodles and three Rhymesbury fields from which bunches had been reaped; second, an estimate of the effectiveness of the pollens in use in relation to one another and to those formerly used at Bodles.

(i) **Notes on individual fields:** Field 12 began shooting in June 1958 and was abandoned in April 1960 solely because of the poor grades of the fruit produced, a factor long known to be detrimental to seed production (Shepherd, 1954 and 1960). In all, 1958 bunches were reaped with 530 seeds, averaging 0.27 seeds per bunch and 6.62 hands per bunch. Only 27 were count bunches, these all in the early part of the plant crop when average grades were highest. Until early June 1959 the only male parent was T27, a cross which was especially revealing because it was also made in a variety of Bodles fields. There, it was estimated that it yielded only half as many seeds as some of the more prolific crosses made about the same time. Seed production from this cross is summarized in Appendix Cyto. 1, from which it can be seen that field 12 gave less seeds than any field at Bodles, although its bunches were of comparable average size. Despite the different periods of operation, slightly over-

lapping, at the two stations, this disparity was probably a genuine one, but no longer one of an alarming magnitude.

The remaining 526 bunches in field 12 were pollinated with a wide variety of more recent male parent selections. These yielded only 61 seeds, an average of 0.12 seeds per bunch of average size 6.38 hands. All of these crosses behaved similarly and they were grossly inferior in seed production to GM x T27, itself a poor seed producer by earlier standards (see Appendix Cyto. 2).

Field 13 began shooting in March 1959 and pollinations to the end of June 1960 had yielded 1481 seeds from 2531 bunches, an average of 0.59 seeds, 7.87 hands. While this was clearly better land than field 12, the average grade had only been kept up with the extravagant use of fertilizers and the best grades were in the early part of the plant crop. In the first three months T27 was used along with other male parents and, as shown in Appendix Cyto. 1, the former averaged over one seed per bunch, still not a remarkable performance in the light of the prevailing bunch sizes, but quite fair for a plant crop. Other crosses have averaged 0.55 seeds per bunch from 2350 bunches, but it was clear in this field that the recent male parents, even those of identical parentage, were far from identical in performance. The best crosses in these fields were even comparable with GM x T27, in contrast with the results in field 12; details are given in Appendix Cyto. 2 and Appendix Cyto. 3. Other comparisons will be considered later.

Field 14 (10 acres) was a much larger area than those previously planted, and the soil type was more suitable for the production of good bananas. The first bunch shot in December 1959 and reappings from pollinations to the end of June totalled 2657, the bulk of the plant crop. These gave 1411 seeds, an average of 0.53 per bunch. Hands averaged 8.12 overall, with best grades in March and April. However, much the best month for pollination was June; the 230 bunches pollinated then yielded 367 seeds. In an area of this size, as could be expected, the quality of fruit was not uniform and seed production would seem to have been equally variable. This latter aspect could well be estimated, however, as there were at one stage four pollinators in the field, each using different male parents. The most prolific sector was that of the senior pollinator, V. Edwards, who used mainly T47, T59, T61 and T62 (see Appendix Cyto. 2 and Cyto. 3). The first ratoon crop started shooting late in 1960 and first indications were that a good proportion of count bunches could be expected, with reasonable prospects of seed yields more generally satisfactory than those to date.

(ii) **Highgate crosses:** Small areas of each of fields 12, 13 and 14 have also been planted with Highgate, since it seemed theoretically possible with recent male parents to get crosses sufficiently longer-fingered than 2390, which would have the merits of shorter stature and greater wind-resistance than corresponding tetraploids from Gros Michel. A comparative estimate of the seed-producing capacity and tetraploid yields of this clone was therefore desirable. Data are also available for an area planted in field 1 at Bodles and pollinated from April 1949 to June 1950, chiefly with Pisang Lilin. Seed yields are summarized in Appendix Cyto. 4.

It will be noted that Highgate averages between one and one and a half hands more than Gros Michel in the same field. Indeed, the fruit in field 12 was considered so poor that, like the Gros Michel planting there, it was abandoned in early 1960. The only cross in this or any Rhymesbury field which had yielded an appreciable number of seeds was x T27, and 100 of the 137 resulted from 27 bunches, 12 of them fertile, pollinated in February and March 1959. For the rest of the year in which these pollinations were done, the cross was scarcely better than the others listed. All of these other crosses have been conspicuously less effective than the corresponding Gros Michel crosses, giving not more than half the number of seeds (cf. Appendix Cyto. 2). Similarly, the Bodles yields cited were less than half those for Gros Michel in the same field. Moreover, this field bore out the evidence of field 12, that yields from Highgate were subject to more dramatic periodic fluctuations than those of Gros Michel. For instance, Highgate x PL pollinated in September 1949 averaged almost two seeds per bunch, (far more than contemporary Gros Michel) whereas those in the two months preceding and the two months following averaged about one-third of a seed per bunch. From December 1949 to February 1950, 35 bunches pollinated averaged 3.17 seeds, when 119 Gros Michel bunches averaged only 2.93. Later, when Gros Michel gave up to four seeds per bunch, the Highgate average fell to 0.5.

Since field 12 was abandoned on the score of poor grades, it was as well to confirm that grade was as important a factor in Highgate as it has been found to be in Gros Michel. In Highgate x PL at Bodles, 207 bunches with 9 hands or less averaged 0.25 seeds, 234 bunches with 10 hands averaged 0.72 seeds, 173 bunches with 11 hands or more averaged 1.44

seeds. In Highgate x T27 in field 12, 117 bunches with 9 hands or less averaged 0.44 seeds, 28 bunches with 10 hands or more averaged 3.15 seeds. The latter included 8 bunches with 81 seeds in the spectacularly successful period referred to above.

Another minor comparison with Gros Michel related to the distribution of seeds between the hands of the bunch. In Gros Michel, roughly half the seeds were set in the first two basal hands, a further quarter in the next two hands. Only the Bodles Highgate data have been similarly analysed. The combination of PL and TI crosses yielded 191 completely pollinated, fertile bunches averaging 10.33 hands and containing 555 seeds. 40% of these were in the first two hands, 29% in the next two, only 31% in from three to eleven remaining hands. Whereas there were 309 seeds in the first three hands, there were only 43 in the last three.

Now having established the inferiority of Highgate to Gros Michel as a seed producer, it was clearly relevant to extend the enquiry to the greenhouse, data from which are summarized in Appendix Cyto. 5. Here it can be seen that, although total germinations from Highgate seeds may or may not exceed those from Gros Michel, the yield of tetraploids was very considerably greater in the former case. So much so that, for recent crosses, the deficiency of seeds in Highgate bunches has been more than compensated. The yield of useful seedlings from a given number of bunches was apparently greater for Highgate.

To conclude, Highgate crosses are still a practical objective and the rate of output of seedlings might be materially increased if Highgate bunches were restricted to those male parents which have proved most effective as seed-producers on Gros Michel, as is now being done.

(iii) **Pollen Comparisons:** The conditions necessary for the accurate comparison of yields from different crosses are rarely attained in normal practice. The considerable fluctuations from month to month and the variation between areas, even between sectors of the same field (Shepherd, 1954 and 1960) make it unsafe to draw rigid conclusions except from crosses which coincide in time and place. At Rhymesbury, a large number of male parents have already been used; their number was being continually augmented by new selections and they were used spasmodically. Pollen of any one was not usually continuously available because there had not as yet been an opportunity to establish a sufficient number of plants, a situation now being remedied.

Appendix Cyto. 3 is intended to give only a general picture, in the knowledge that at least some of the apparent differences are unreliable. The points to be made from it are the magnitude of these differences in performance between male parents of the same or similar parentage and the fact that some of them performed quite satisfactorily in favourable conditions.

The comparisons of Appendix Cyto. 4 all fulfilled the conditions of coincidence in time and place, although they might not be exactly comparable in other respects. They are precise enough to permit quite a number of male parents to be put in order of effectiveness. Apart from one anomalous result in field 14, T52 was almost equal to T27, rather better than T54, which in turn was distinctly better than a group comprising T36, T53 and T34. Separately, T61 was much better than T62, which was itself much better than T59.

The essential conclusion is that the major factor in poor seed production at Rhymesbury was the employment of relatively ineffective pollen. The practical consequence is that each new male parent in future should be submitted to some controlled trial of its seed-setting capacity on Gros Michel at the earliest stage, certainly before it has entered extensively into the Rhymesbury programme.

C. Greenhouse Germinations

While the output of seedlings from Gros Michel seeds had been under almost continuous review since 1950, events in the Bodles greenhouse had received only intermittent attention, despite the sometimes conspicuous scarcity of young seedlings in the winter months. A comprehensive survey is in progress which will finally summarize the history of all sowings since 1948. However, the data examined to date, on PL, T14 and T16 crosses warrant an interim report for the light they throw on a critical aspect of germination behaviour, that of seasonal variation. The usable data are summarized in Appendix Cyto. 6 for sowings in the half-yearly periods September to February, and March to August. These dates were chosen because they revealed the greatest average contrast, but they could also be considered to be centred on the mid-winter and mid-summer periods, inasmuch as there was normally a lag of about a month between sowing and the first germinations.

The following points are clearly made:

1. germinations are drastically reduced by winter sowing;
2. tetraploid seeds are more adversely affected than other classes;
3. with optimal greenhouse conditions throughout the year it might have been possible to achieve a tetraploid yield of over 15% from GM x T16 seeds whereas the actual average for more than four years of sowings was 8.9%. The maximum output was in fact about 20% for a shorter period of 1955 (246 tetraploids of 642 germinations from 1244 seeds sown in the period April to June).

Two practical possibilities suggested themselves. The first was to store seeds harvested between, say, mid-August and February each year for mass sowing not earlier than mid-March. This would depend on means of storage which would not significantly depress viability. Experiments on seeds of the wild *Musa balbisiana* showed that viability could be maintained for six months in the laboratory, or two years in a desiccator (Simmonds 1952), but it must be confirmed that this result applies also to Gros Michel seeds or those from other edible clones. One such experiment is being set up, initially, with secondary triploid seeds. There is little reason, on past experience, to doubt that such storage is possible, but the suggested practice would place a considerable strain on greenhouse facilities. The second possibility is to determine what is the limiting factor for winter germinations. The most likely is temperature and particularly night temperature and an experiment is to be started in January 1961 to examine this.

The United Fruit Company have kindly provided details of an unpublished technique devised by some of their research staff (R. D. Goos, et al.) for the rapid germination of *M. balbisiana* seeds. This technique is also under trial with a view to its wider application.

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APPENDIX

Phys. 1. NUTRITION OF THE BANANA PLANT: NUTRIENT UPTAKE EXPERIMENT, ST. THOMAS.

Soil Analysis

Depth	pH	ppm		m.g.e./100 g.	
		P ₂ O ₅	K ₂ O	Ca	Mg
0-9 ins.	7.1	23.5	188	53	5
9-18 ins.	7.6	1.0	147	51	5

Layout: 5 Randomized Blocks

Main Treatments:

1. Control
2. 1 lb. ammonium sulphate (21%N)/mat/year
3. 1 lb. di-ammonium phosphate (21%N, 53%P₂O₅)/mat/year
(4 quarterly applications)

Sub-treatments:

- A. Control
- B. ¼ lb. kieserite (27%MgO)/mat/year
(single application in March)

Size of Plot: 6 mats

Results (interim):

Leaf Analysis (Mean Values, %)

Constituent	Plot 1A	1B	2A	2B	3A	3B
N	3.09	3.07	3.18	3.32	3.11	3.13
P ₂ O ₅	0.40	0.41	0.39	0.42	0.42	0.42
K ₂ O	3.78	4.00	3.90	4.21	4.03	3.90
CaO	1.18	1.16	1.31	1.31	1.19	1.12
MgO	0.53	0.51	0.54	0.51	0.56	0.51

Yield (total)

Total Stems	10	4	1	4	4	5
Exportable Stems	10	4	1	3	4	5
Count Bunches	5.25	2.25	0.25	1.75	1.75	2.75

Phys. 2. NUTRITION OF THE BANANA PLANT: NUTRIENT UPTAKE EXPERIMENT, PORTLAND (1).

Soil Analysis

Depth	pH	ppm	
		P ₂ O ₅	K ₂ O
0-9 ins.	6.1	17.0	109
9-18 ins.	6.0	16.5	56

Layout: 5 Randomized Blocks

Main Treatments:

1. 1 lb. di-ammonium phosphate (21%N, 53%P₂O₅)/mat/year
2. 1 lb. ammonium sulphate (21%N)/mat/year
(4 quarterly applications)

Sub-treatments:

- A. Limed — 3 tons ground limestone/acre/2 years
- B. Not limed
(single application)

Size of Plot: 12 mats

Results (interim):

Leaf Analysis (Mean Values %)

Constituent	Plot 1A	1B	2A	2B
N	2.80	2.84	2.91	2.82
P ₂ O ₅	0.52	0.51	0.42	0.47
K ₂ O	3.42	3.77	3.54	4.02
Ca	0.78	0.84	0.93	0.91
Mg	0.51	0.48	0.49	0.52

Yields (acre)

					LSD (P=0.05)
Total Stems	330	260	310	290	40.6
Exportable Stems	250	200	250	220	43.1
Count Bunches	112.5	102.5	120.0	107.5	25.3

Phys. 3.

NUTRITION OF THE BANANA PLANT: NUTRIENT UPTAKE EXPERIMENT, PORTLAND (2).

Soil Analysis

Depth	pH	ppm	
		P ₂ O ₅	K ₂ O
0-9 ins.	5.5	4.5	93
9-18 ins.	5.8	3.0	56

Treatments: (duplicate)

1. ¼ lb. kieserite/mat/year
2. 4 tons lime/acre/2 years
3. Treatment 1 + ¼ lb. di-ammonium phosphate/mat/year
(4 quarterly applications)

Results:

Leaf Analysis (Mean Values %)

Constituent	1	2	3
N	2.43	2.79	2.71
P ₂ O ₅	0.44	0.48	0.51
K ₂ O	4.10	3.97	3.77
Ca	0.86	0.89	0.77
Mg	0.55	0.59	0.55

Yields/acre

Total Stems	66	148	136
Marketable Stems	14	64	69
Count Bunches	4.3	27.3	25.5

Phys. 4.

SUCKER PRODUCTION: GIBBERELLIN TRIAL

Experimental Treatments	Suckers Planted	Deaths (replanted)	Total suckers obtained
Control	6	2	31
GA dip 100 ppm	6	4	3
GA spray 1.875 mg	6	3	14
" 0.375 mg	6	2	10
" 0.0375 mg	6	2	18
GA paste 1.875 mg	6	4	23
" 0.375 mg	6	2	38
" 0.0375 mg	6	2	42

Phys. 5. **SUCKER PRODUCTION: PRUNING TRIAL, BODLES. Initiated 1959.**

Layout: 4 Randomized Blocks

Main Treatments:

1. First sucker selected as follower
2. April and August suckers selected as followers
3. Follower selected at bulling

Sub-treatments:

- A. Unwanted suckers removed monthly
- B. Unwanted suckers removed only at time of follower selection.

Results 1960

Treatment	Mean no. suckers/mat (including regrowths)	Fruit/mat Reaped 1960			Shot but not reaped	
		Stems	Counts	Weight lbs.	Stems	Counts
1A	20.8	1.75	1.73	102.9	0.21	0.21
B	12.3	1.25	1.25	88.3	0.75	0.75
2A	13.1	1.50	1.49	88.2	0.38	0.38
B	12.4	1.71	1.71	109.1	0.25	0.24
3A	16.5	1.17	1.11	70.5	0.58	0.58
B	12.4	1.21	1.17	73.2	0.63	0.63
LSD (P=0.01)	2.3	0.31		28.4		

Phys. 6. **SUCKER PRODUCTION: PRUNING TRIAL, GOLDEN VALE.**

Layout: 2 Latin Squares 5 x 5

Treatments:

1. Suckers plucked.
2. Suckers cut at ground level and left untreated.
3. Suckers cut at ground level and cut surface smeared with 2,4-D paste (5% A.E.).
4. Suckers injected with 2,4-D solution (1% A.E.).
5. Suckers injected with kerosene.

Mean Production of Undesired Suckers/Mat — 1960

Treatment	No. of suckers
1	7.4
2	10.4
3	8.6
4	5.3
5	5.5
LSD (P=0.01)	1.6

Phys. 7. **OPENHANDEDNESS: TIMING THE NITROGEN APPLICATIONS (PLANT CROP)**

(1) Field Experiment 4

Treatments:

1. N as ammonium sulphate applied through crop life
2. N as ammonium sulphate/nitrate applied throughout crop life
3. N as ammonium sulphate, applications completed before flowering.
4. N as ammonium sulphate/nitrate, applications completed before flowering.

Plot size: 24 mats spaced 403/ac.

Results:

Treatments	Yield/ac.		Mean Openhandedness
	Stems	Counts	
1	378	222.7	0.68
2	382	204.8	0.55
3	387	208.0	0.45
4	395	220.2	0.43
LSD (P=0.01)			0.18

(2) Field Experiment 6

Treatments:

1. N as ammonium sulphate
2. N as ammonium sulphate/nitrate
3. N as urea

Sub-treatments:

- A. Applications made throughout crop life
- B. Applications completed in the 1st six months of growth
- C. Applications made after 6 months' growth

Plot size: 16 mats spaced 900/ac.

Treat-ments	A			B			C		
	Yield/ac		Open-handed-ness	Yield/ac		Open-handed-ness	Yield/ac		Open-handed-ness
	Stems	Counts		Stems	Counts		Stems	Counts	
1	731	553.1	0.6	731	506.1	0.5	788	557.8	0.8
2	750	501.6	0.5	703	478.1	0.7	675	464.1	0.6
3	806	567.2	0.4	769	543.8	0.6	703	510.9	0.5

Phys. 8. FRUIT INVESTIGATIONS: PERCENTAGE LOSS IN WEIGHT OF BANANAS HELD AT THE FIELD STAND.

Weight group	Bordeaux-sprayed			Oil-sprayed			Unsprayed		
	8 hrs	24 hrs	48 hrs	8 hrs	24 hrs	48 hrs	8 hrs	24 hrs	48 hrs
Under 30 lb	0.24	0.70	1.61	0.00	0.64	1.43	1.26	0.63	1.88
30 - 40 lb	0.17	0.98	1.75	0.23	0.72	1.50	0.00	0.36	2.53
40 - 50 lb	0.17*	0.57	1.25	0.13	0.56	1.50	insufficient fruit		
Over 50 lb	0.77	1.24	1.87	0.23	0.60	1.22	0.98	1.96	3.43

* Anomalous gain in weight.

Phys. 9. FRUIT INVESTIGATIONS: EFFECTS OF OIL-SPRAYING

Mean Wt. of Bunches in lbs.

Source	9 hands	8 hands	7 hands	6 hands
Caenwood:				
Bordeaux	47.1	38.0	32.3	20.0*
Oil	39.3	34.6	28.7	22.8
Unsprayed	46.9	35.8	27.4	21.9
LSD (P=0.05)	6.4	5.2	3.6	
Orange River:				
Bordeaux	42.6	37.7	32.7	25.0*
Oil	46.1	35.5	27.9	22.7
LSD (P=0.05)	6.4	4.0	3.6	

* Insufficient fruit for valid comparison.

Numbers and Mean Length (ins.) of Fingers

Butt End

	no.	mean length	no.	mean length	no.	mean length	no.	mean length
Caenwood:								
Bordeaux	18.7	10.0	18.0	9.8	16.0	9.2	16.0	9.0
Oil	21.5	10.5	18.0	10.0	17.1	9.6	16.0	9.0
Unsprayed	18.9	10.1	18.1	9.6	15.7	9.1	15.7	9.2
Orange River:								
Bordeaux	20.0	10.1	17.3	10.1	16.1	9.3	15.0	9.0
Oil	20.1	10.5	18.6	9.6	16.7	9.4	14.3	9.3

Tip End

Caenwood:								
Bordeaux	14.8	8.3	14.2	8.2	13.5	8.0	14.0	8.0
Oil	14.0	8.0	14.3	8.2	13.8	8.4	13.3	8.0
Unsprayed	14.3	8.1	14.2	7.9	13.0	7.8	12.3	8.0
Orange River:								
Bordeaux	15.3	8.2	14.3	8.2	12.9	8.1	11.0	8.0
Oil	15.4	8.5	14.1	8.0	13.4	8.2	12.5	8.3

Mean Weights (oz.) and Volumes (c.c.) of Fingers.

Butt End

Grade and Treatment	Caenwood									Orange River														
	9 hands			8 hands			7 hands			6 hands			9 hands			8 hands			7 hands			6 hands		
	wt.	vol.		wt.	vol.		wt.	vol.		wt.	vol.		wt.	vol.		wt.	vol.		wt.	vol.		wt.	vol.	
F	Bordeaux	4.8	144	4.4	137	4.3	130	—	—	—	—	—	—	—	—	5.4	155	5.2	149	4.9	148	4.4	127	—
	Oil	—	—	—	5.5	155	4.5	138	—	—	—	—	—	—	—	—	5.7	168	5.2	147	5.0	142	5.4	162
F $\frac{3}{4}$	Bordeaux	4.6	136	4.4	132	3.9	131	—	—	—	—	—	—	—	—	—	5.5	158	4.2	127	3.9	122	—	—
	Oil	—	—	—	5.0	146	4.1	129	3.6	113	5.2	152	4.2	123	4.1	126	—	—	—	—	—	—	—	—
LF $\frac{3}{4}$	Bordeaux	4.5	133	3.0	121	4.6	145	4.3	121	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Oil	4.9	146	4.2	125	3.4	108	3.4	108	3.4	125	3.4	103	4.2	129	4.9	135	—	—	—	—	—	—	
Unsprayed	Oil	5.1	149	4.4	133	3.8	121	2.9	143*	3.7	111	3.6	115	3.9	119	—	—	—	—	—	—	—	—	—
	Unsprayed	4.0	121	3.7	117	3.4	108	3.6	131	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
$\frac{3}{4}$	Bordeaux	3.8	106	4.2	127	3.7	121	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Oil	2.8	89	3.9	121	4.0	131	3.8	120	3.7	115	3.3	99	—	—	—	—	—	—	—	—	—	—	—
Unsprayed	4.2	129	3.6	120	3.4	118	3.4	123	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Tip End

F Bordeaux Oil	3.5	107	3.3	101	3.2	107	—	—	—	—	—	—	3.9	115	3.9	110	3.7	111	3.5	100	—	—	—	—
Unsprayed	—	—	3.4	99	3.2	99	—	—	—	—	—	—	4.0	116	3.9	109	3.7	105	4.2	120	—	—	—	—
F $\frac{1}{4}$ Bordeaux Oil	3.3	97	3.3	100	2.9	112	—	—	—	—	—	—	3.8	110	3.3	100	3.1	104	—	—	—	—	—	—
Unsprayed	3.1	93	3.3	100	3.1	103	3.1	101	3.6	105	3.2	91	—	—	—	—	—	—	—	—	—	—	—	—
LF $\frac{1}{4}$ Bordeaux Oil	3.4	99	3.0	89	2.8	96	2.6	111	2.6*	78	3.2	100	3.7	106	—	—	—	—	—	—	—	—	—	—
Unsprayed	2.9	89	3.1	87	2.5	95	2.7	86	2.8	84	2.8	96	3.2	102	2.9	85	—	—	—	—	—	—	—	—
$\frac{3}{4}$ Bordeaux Oil	2.9	74	3.1	98	2.8	101	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unsprayed	2.4	76	2.8	92	3.1	102	2.9	110	2.9	89	2.7	89	2.7	89	2.7	89	2.7	92	—	—	—	—	—	—
	3.1	97	2.9	96	2.8	104	2.9	110	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* Single Bunch

Phys. 11.

FRUIT INVESTIGATIONS: EFFECTS OF OIL SPRAYING

Dry Matter Content of Fingers in Grammes.

Treatment	Caenwood	Orange River
Unsprayed	21.6	—
Bordeaux-sprayed	23.4	23.9
Oil-sprayed	21.1	23.0

Phys. 12.

WEED CONTROL: DALAPON SPRAYING TRIAL, BELVEDERE

Layout: 4 x 4 Latin Square

Treatments:

1. High-volume spray 5 lb dalapon in 25 gallons per acre.
2. Low-volume spray 5 lb dalapon in 5 gallons per acre.
3. Low-volume spray 2 lb dalapon in 5 gallons per acre.
4. Low-volume spray 1 lb dalapon in 5 gallons per acre.

Size of Plot: ½ acre

Estimate % Weediness (Grasses)

Treatment	June 29	Aug. 18	Sep. 28
1	84	15	30
2	74	21	42
3	83	47	36
4	79	39	30

Chem. 1.

MICRONUTRIENT TRIAL — ST. MARY

Layout: 4 randomized blocks. Plot size 4 mats.

Treatments: (soil and foliar applications carried out twice per year).

1. Control
2. Magnesium — ¼ lb/root of Kieserite as a soil application
3. Manganese — ¼ lb/root of Manganese-chelate soil application
4. Iron — ¼ lb/root of Fe-chelate " "
5. Zinc — ¼ lb/root of Zn-chelate " "
6. Esminel — 5% Esminel solution as a foliar spray application
7. Boron — 5% Borax " " " " " "
8. Molybdenum — 0.3% Sodium Molybdate as a " " " " " "

Analysis Data for First Ratoon Crop

Treatments	Days to Shooting*	Height at Shooting	Girth of Pseudostem at Shooting	No. of Hands Per Stem
1	155.4	120.5	6.5	7.2
2	165.6	123.7	6.6	6.9
3	191.8	122.4	6.8	6.7
4	185.9	128.0	6.7	7.4
5	176.1	115.9	6.1	6.1
6	148.8	121.9	6.6	7.2
7	206.1	116.1	6.1	6.7
8	188.6	123.6	6.2	6.7
Sig. Diff. P,0.05	63.6	15.8	0.74	1.58
P,0.01	86.6	21.4	1.01	2.15
C.V.	24.4	8.8	7.8	15.5

* Calculated from 1-5-59.

Chem. 2.

pH VALUES OF AFFECTED AND UNAFFECTED AREAS
ON WAIT-A-BIT CLAY

Site	Depth in inches	pH of affected area	pH of unaffected area
I	0-9	7.7	5.7
	9-18	7.7	6.2
II	0-9	7.7	5.4
	9-18	7.3	5.4
III	0-9	8.5	6.7
	9-18	8.0	6.9
IV	0-9	7.8	5.2
	9-18	6.9	5.0

Chem. 3.

MANGANESE DEFICIENCY TRIAL

Fruit condition of experimental plants at Hopewell, St. Mary, receiving various foliar treatments and one soil treatment.

Treatment Received	Fruit condition of plant A	Fruit condition of plant B
(1) 2% Magnesium Sulphate	very slight severe	severe
(2) 1% Manganese Sulphate		very slight
(3) 1% Ferrous Sulphate		severe
(4) 1% Borax	medium (plant toppled over) (cut back)	severe
(5) 1% Ammonium Molybdate		medium
(6) 1% Zinc Sulphate		severe
(7) Sulphur (soil application)	severe	medium
(8) Control		
(9) 1% Ammonium Molybdate		
(10) 1% Ammonium Sulphate	severe	

Chem. 4. MEAN LEAF ANALYSIS FIGURES FOR 16 AFFECTED AND 16 UNAFFECTED BANANAS AT HOPEWELL, ST. MARY

	%N	%P ₂ O ₅	%K ₂ O	%CaO	%MgO	Manganese ppm	Iron ppm	Copper ppm	Boron ppm	% Ash	Strontium ppm	Barium ppm	Sodium ppm
Affected Plants	3.89	0.48	4.47	1.58	0.48	19.1	89.1	14.5	13.0	10.68	187.5	20.6	< 30
Unaffected Plants	3.39	0.41	3.43	1.76	0.46	58.3	66.9	11.2	9.8	9.11	58.6	16	< 30
t	5.86	6.26	6.32	2.04	0.83	9.53	3.33	4.63	2.99	1.82	7.22	2.59	

t (.05 level) = 2.04
 .01 " = 2.75
 .001 " = 3.63

Anal. 1.

**DIURNAL VARIATION OF N,P,K IN THE SECOND FULLY
OPENED LEAF OF A STAGE 2 BANANA PLANT**

TIME	% N	% P ₂ O ₅	% K ₂ O	% H ₂ O	R.H.	TEMP. °F	LEAF
6 a.m.	3.77	0.65	5.75	80.9	82	72	Fully expanded
7 a.m.	3.50	0.63	5.28	79.8	78	73	"
8 a.m.	3.57	0.66	5.18	80.4	68	80	"
9 a.m.	3.88	0.63	5.26	80.0	46	88	"
10 a.m.	3.52	0.62	5.16	80.1	56	84	Wilted
11 a.m.	3.52	0.63	5.16	80.8	69	83	Partially expanded
12 noon	3.97	0.62	4.55	79.3	57	89	Wilted
1 p.m.	3.51	0.70	4.75	79.2	47	90	Wilted
2 p.m.	3.51	0.62	5.15	78.9	42	93	Wilted
3 p.m.	3.98	0.79	5.23	85.2	47	91	Partially expanded
4 p.m.	3.64	0.66	5.16	80.1	57	88	"
5 p.m.	3.69	0.74	5.26	80.4	46	87	Fully expanded
Mean	3.67	0.66	5.16				
SD	±0.19	±0.05	±0.29				
CV	1.4%	2.3%	1.6%				

Anal. 2.

ANALYSIS OF WILTED AND NON-WILTED LEAF SAMPLES

Treatments	% N	% P ₂ O ₅	% K ₂ O	% CaO	% MgO
Non-Wilted	3.19	0.47	3.83	1.30	0.53
Wilted	2.94	0.49	3.66	1.21	0.55

Anal. 3.

**LEAF ANALYSES OF 3 x 3 x 3 NPK FACTORIAL EXPERIMENTS SHOWING
NUTRIENT RESPONSE IN THE PLANT TO FERTILIZER APPLICATIONS**

3 blocks each at 3 different sites and each of 9 plots

Treatments:

(N) Sulphate of Ammonia } all at
(P) Single Superphosphate } 0, ¼ lb., ½ lb.
(K) Muriate of Potash } per mat 3 times/year

	SITE	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	CV
Nitrogen %N	I	2.96	3.28	3.00	3.18	3.17	2.89	3.04	3.17	3.04	12.1
	II	3.57	3.72	3.56	3.64	3.58	3.63	3.64	3.47	3.75	9.1
	III	3.15	3.05	3.18	3.10	3.02	3.26	3.14	3.10	3.14	8.4

Sign. Diff. None

Phosphate %P ₂ O ₅	I	0.45	0.45	0.41	0.43	0.45	0.43	0.43	0.43	0.45	11.1
	II	0.46	0.43	0.42	0.42	0.46	0.44	0.44	0.43	0.45	22.7
	III	0.49	0.44	0.44	0.45	0.43	0.48	0.45	0.45	0.46	1.5

Sign. Diff. None

Potash %K ₂ O	I	3.68	3.74	3.57	3.68	3.74	3.55	3.66	3.57	3.74	5.1
	II	4.48	4.36	4.21	4.40	4.40	4.25	4.34	4.19	4.52	9.2
	III	4.71	4.53	4.36	4.67	4.49	4.44	4.35	4.65	4.60	11.6

Sign. Diff. Site I — Blocks***, NK*, PK*, Site II — Blocks***

Calcium %CaO	I	1.06	1.14	1.19	1.13	1.16	1.10	1.07	1.13	1.18	12.0
	II	1.07	1.03	1.16	1.19	0.99	1.07	1.04	1.08	1.13	15.1
	III	2.17	2.20	2.11	2.30	2.11	2.10	2.26	2.15	2.08	20.5

Sign. Diff. Site I — Blocks***, NK*

Magnesium %MgO	I	0.49	0.52	0.49	0.47	0.50	0.52	0.50	0.49	0.50	8.7
	II	0.57	0.50	0.52	0.52	0.54	0.52	0.59	0.51	0.50	14.9
	III	0.54	0.51	0.52	0.54	0.52	0.51	0.54	0.49	0.53	19.6

Sign. Diff. Site I — PK*

BLOCKS				Least Sign. Diffs. at		
	I	II	III	P 0.05	P 0.01	P 0.001
Potash — Site I	4.08	3.66	3.24	0.20	0.30	0.48
Potash — Site II	4.54	4.61	3.90	0.46		
Calcium — Site I	1.61	0.87	0.91	0.16	0.24	0.39

Anal. 4. LEAF ANALYSES OF 3 x 3 x 3 NPK FACTORIAL EXPERIMENT ('CLEAN' SUCKERS) SHOWING NUTRIENT RESPONSES IN THE PLANT TO FERTILIZER APPLICATIONS

3 Blocks each of 9 plots

Treatments:

(N) Sulphate of Ammonia } all at
(P) Single Superphosphate } 0, ¼ lb., ½ lb.
(K) Muriate of Potash } per mat 4 times/year

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	CV
Nitrogen (%N)	3.33	3.72	3.92	3.79	3.55	3.64	3.75	3.62	3.61	8.9
Sign. Diff. N — treatments* (P 0.05 = 0.38)										
Phosphate (%P ₂ O ₅)	0.45	0.48	0.50	0.45	0.48	0.49	0.48	0.46	0.48	8.5
Sign. Diff. None										
Potash (%K ₂ O)	4.47	4.08	3.87	4.17	4.20	4.05	3.77	4.27	4.37	8.1
Sign. Diff. Blocks*, N — treatments* (P 0.05 = 0.38), K — treatments* (P 0.05 = 0.38)										
Calcium (%CaO)	0.76	0.71	0.68	0.79	0.65	0.71	0.70	0.76	0.69	24.3
Sign. Diff. None										
Magnesium (%MgO)	0.54	0.56	0.49	0.60	0.45	0.53	0.53	0.50	0.55	15.7
Sign. Diff. P — treatments (P 0.05 = 0.10)										

	BLOCKS			Least Sign. Diff.
	I	II	III	P 0.05
Potash	4.16	4.49	3.77	0.38

Anal. 5. LEAF ANALYSES OF 3 x 2 x 2 NPK FACTORIAL EXPERIMENTS SHOWING NUTRIENT RESPONSE IN THE PLANT TO FERTILIZER APPLICATION

12 plots each at 2 different sites

Treatments:

(N) Ammonium Sulphate 0, ¼, ½ lb. }
(P) Single Superphosphate 0, ½ lb. } 3 times/year
(K) Muriate of Potash 0, ½ lb. }

	SITE	N ₀	N ₁	N ₂	P ₀	P ₁	K ₀	K ₁	CV
Nitrogen % N	I	2.39	2.46	2.55	2.44	2.49	2.57	2.36	10.6
	II	2.75	2.78	2.57	2.78	2.62	2.81	2.58	
Sign. Diff. None									
Phosphate % P ₂ O ₅	I	0.59	0.49	0.49	0.50	0.55	0.52	0.43	6.0
	II	0.43	0.44	0.45	0.44	0.45	0.53	0.46	
Sign. Diff. Sites***, N — treatments* (P 0.05 = 0.04), NP*, Sites* N*									
Potash % K ₂ O	I	4.53	4.46	4.46	4.37	4.59	4.32	4.64	12.9
	II	3.21	3.27	3.28	3.27	3.23	3.20	3.30	
Sign. Diff. Sites***									
Calcium % CaO	I	1.25	1.20	1.31	1.14	1.36	1.30	1.20	13.7
	II	1.97	1.63	1.98	1.85	1.87	2.02	1.70	
Sign. Diff. Sites***, K — treatments* (P 0.05 = 0.18)									
Magnesium % MgO	I	0.89	0.83	0.80	0.78	0.90	0.91	0.77	21.3
	II	0.50	0.57	0.52	0.48	0.58	0.54	0.51	
Sign. Diff. Sites***									

	SITES		Least Sign. Diff. at		
	I	II	P 0.05	P 0.01	P 0.001
Phosphate	0.52	0.44	0.03	0.04	0.06
Potash	4.48	3.25	0.49	0.70	1.03
Calcium	1.25	1.86	0.16	0.26	0.39
Magnesium	0.84	0.53	0.13	0.19	0.27

Anal. 6. EFFECT OF STAGE OF DEVELOPMENT ON NUTRIENT RATIOS

Stage of Plant Development	N/T	P ₂ O ₅ /T	K ₂ O/T	Plant crop	Ratoon crop
Stage 1	0.42	0.07	0.51	Under 6 months	Opening of the first blunt leaf to death of the last pointed leaf.
Stage 2	0.41	0.06	0.52	6-8 months	From the shedding of the last pointed leaf until $\frac{2}{3}$ grown or before initiation of flowering.
Stage 3	0.39	0.07	0.54	9 months-shooting	$\frac{2}{3}$ grown to emergence of inflorescence.
'shot'	0.39	0.07	0.51	'shot'	Inflorescence visible, fruit development.

Ag. 1. (a) NPK TRIALS — 33 FACTORIAL EXPERIMENT — ST. MARY

Layout: 3 Blocks of 9 plots each

Treatments:

N — Sulphate of Ammonia
P — Single Superphosphate
K — Muriate of Potash

} all at 0, ¼ lb., ½ lb. per mat.
applied 3 times per annum

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	Sig. Diff. P.05	Coef. Var. (% G.M.)
Nos. shot	23.6	24.8	29.4	27.0	27.6	23.2	25.7	25.1	27.0	7.8	17.9
Av. No. hands/stem	6.26	6.04	6.35	6.20	6.35	6.09	6.03	6.17	6.45	.48	4.6
Av. wt./hand (lbs.)	4.24	4.08	4.33	4.18	4.34	4.14	4.09	4.22	4.35	.33	4.6
Total wt. fruit	663.8	667.8	821.9	739.2	765.6	648.7	667.1	703.6	783.1	195.8	16.2

(b) NPK TRIALS — 33 FACTORIAL EXPERIMENT — ST. MARY

Layout: 3 Blocks of 9 plots each

Treatments:

N — Sulphate of Ammonia
P — Single Superphosphate
K — Muriate of Potash

} all at 0, ¼ lb., ½ lb. per mat.
applied 3 times per annum

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	Sig. Diff. P.05	Coef. Var. (% G.M.)
Av. No. shot/plot	24.9	29.1	32.8	29.1	28.7	29.0	27.8	28.0	31.0	5.9	12.1
Av. No. hands/stem	6.06	6.49	6.86	6.40	6.54	6.47	6.24	6.45	6.74	.80	7.4
Av. wt./hand (lbs.)	4.21	4.35	4.32	4.27	4.27	4.34	4.22	4.27	4.33	.29	3.9
Total wt. fruit/plot	639.3	824.1	977.7	810.7	805.0	825.4	738.8	777.9	924.4	275.3	20.1

(c) NPK TRIALS — 33 FACTORIAL EXPERIMENT — ST. MARY

Layout: 3 Blocks of 9 plots each

Treatments:

N — Sulphate of Ammonia
P — Single Superphosphate
K — Muriate of Potash

} all at 0, ¼ lb., ½ lb. per mat.
applied 3 times per annum

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	G.M.
Av. No. shot/plot	29.7	27.3	32.7	27.3	32.3	30.0	27.7	30.0	32.0	29.9
Av. No. hands/stem	6.1	6.1	6.5	5.5	6.9	6.3	5.5	6.2	7.0	6.2
Av. wt./hand (lbs.)	4.09	4.12	4.11	3.69	4.53	4.09	3.55	4.26	4.51	4.11

No analysis

(d) NPK TRIALS — 33 FACTORIAL EXPERIMENT — ST. THOMAS

Layout: 3 Blocks of 9 plots each

Treatments:

N — Sulphate of Ammonia
P — Single Superphosphate
K — Muriate of Potash

} all at 0, ¼ lb., ½ lb. per mat.
applied 3 times per annum

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂	Least Sig. Diff. P.05	Coef. Var. (% G.M.)
Av. No. hands/stem	5.87	5.69	6.16	6.01	5.79	5.92	5.74	5.83	6.15	.78	7.9
Av. wt./hand (lbs.)	3.76	3.62	3.90	3.76	3.70	3.71	3.71	3.74	3.72	.48	7.7

Agr. 2. NEMAGON + FERTILIZER — ST. CATHERINE PLAINS

Layout: Randomized block — 3 replications

Treatments:

N₀ — untreated
 N₁ — 3.5 i.g. N/acre or 4.66 i.g. 75% E.C./acre
 N₂ — 5.0 " " 6.66 " "
 F₁ — 3 oz./plant per month Amm. Sulphate
 F₂ — 6 " " " " "

Application of Nemagon was by "overall" injection method at 12" spacing and 8" depth using 5 ml./injection. Each plot consisted of 24 plants — 12 plants recorded.

	N ₀	N ₁	N ₂	F ₁	F ₂	G.M.	Least Sig. Diff. for N P 05	Least Sig. Diff. for F P 05	Coeff. Var. (% G.M.)
Av. No. days to shooting	263.1	274.2	266.0	267.3	268.2	267.8	17.1	15.5	3.7
Av. No. hands/stem	7.89	8.15	8.19	8.10	8.06	8.08	.24	.22	1.7
Av. wt./hand (lbs.)	5.64	5.55	5.67	5.58	5.65	5.62	.45	.40	4.7

(a) Portland

	Experimental Pruning	Standard Est. Pruning
Shot up to 31st Dec. 1960	268.4 %	263.8 %
Reaped up to 31st Dec. 1960	236.3 %	226.1 %
Reaped during foll. periods:		
Feb. 1959-March 1959	18.4 %	23.9 %
April 1959-Sept. 1959	76.7 %	64.8 %
Oct. 1959-March 1960	59.6 %	53.4 %
April 1960-Sept. 1960	42.9 %	52.0 %
Oct. 1960-Dec. 1960	38.7 %	29.8 %
Losses of fruit from high winds	8.0 %	9.7 %
Losses of plants from high winds	15.3 %	18.4 %

(b) Portland

	Experimental Pruning	Standard Est. Pruning
Shot up to 31st Dec. 1960	207.4 %	201.0 %
Reaped up to 31st Dec. 1960	169.4 %	158.6 %
Reaped during foll. periods:		
Dec. 1958-March 1959	14.1 %	18.2 %
April 1959-Sept. 1959	56.7 %	59.6 %
Oct. 1959-March 1960	41.4 %	33.0 %
April 1960-Sept. 1960	38.4 %	32.1 %
Oct. 1960-Dec. 1960	18.8 %	15.7 %
Losses from theft, "toppling over" and wind	23.0 %	21.7 %

(c) St. Mary

	Experimental Pruning	Standard Est. Pruning
Shot by 31st Dec. 1960	161.0 %	150.6 %
Reaped by 31st Dec. 1960	153.2 %	145.0 %
Reaped during the foll. periods:		
Jan. 1959-March 1959	7.1 %	11.1 %
April 1959-Sept. 1959	42.6 %	55.3 %
Oct. 1959-March 1960	42.1 %	29.4 %
April 1960-Sept. 1960	47.6 %	38.5 %
Oct. 1960-Dec. 1960	13.8 %	10.7 %

Path. 1.

NEMAGON INJECTION EXPERIMENT 1.

Layout: Bog Walk. Lacatan. Part of field had $\frac{1}{2}$ oz. of Nemagon granules put into each planting hole at time of planting, July 1958.
6 Randomized Blocks. 3 Main treatments, 2 sub-treatments.
Total No. plants = 864.

Treatments:

The Nemagon emulsion used throughout the first application, 16-21 April, 1959, was 5 l.g. Nemagon 75% E.C. + 1.6 l.g. water. Second application proportions were 25/75 NEC/water.

A. 5 ml. NEC/water per injection, at 8" depth

B. 10 ml. NEC/water " " " " "

C. Untreated.

Method of Application:

1. One ring of 4 injections, 1 ft. from plant.
2. Two rings of injections, 1 ring of 4 injections 1 ft. from plant and 1 ring of 8 injections at 2 ft. from plant.

No. of applications:

- (i) Once a year — April 1959.
- (ii) Twice a year — April 1959, Jan. 1960.

		PLANT CROP		FIRST RATOON CROP		
TREATMENTS		Ht. of shooting (inches)	Grade (No. Hands)	Ht. of shooting (inches)	Grade (No. Hands)	Days to shooting (1)
NEMAGON	O	101	7.54	130	9.25	186
	N	102	7.64	131	9.79	193
	2N	99	7.52	133	9.73	180
Sign. Diff.		—	—	—	0.36**	—
C.V.		5.0%	5.5%	3.7%	4.1%	21.9%
NO. RINGS	1.	102	7.56	132	9.61	187
	2.	100	7.58	132	9.56	185
Sign. Diff.		—	—	—	—	—
C.V.		4.6%	2.8%	2.7%	5.5%	8.3%
APPLICATION	i.	101	7.64	132	9.71	188
	ii.	100	7.49	131	9.47	184
Sign. Diff.		—	—	—	0.21*	—
C.V.		4.7%	5.5%	3.8%	4.6%	—

(1) Calculated from 1/1/60.

** P,0.01; * P,0.05

Path. 2.

NEMAGON INJECTION EXPERIMENT 2.

Layout: St. Catherine Irrigated. 4 Randomized Blocks. Total No. Plants 3,480.
Lacatan. Planted w/e 19/7/58. 2 Nemagon Treatments.

Planting Treatments:

- A. Nemagon granules (10 g.) dusted in planting hole (mixed with 20 g. Gypsum)
- B. Nemagon granules (20 g.) " " " " (mixed with 40 g. Gypsum)
- C. Nemagon, 75% Emulsifiable Concentrate (1 in 25) sprayed on to head in planting hole (approx. 100 ml.)
- D. Nemagon, 75% Emulsifiable Concentrate (1 in 50) sprayed on to head in planting hole (approx. 100 ml.)
- E. Untreated.

Injection Treatments:

Nemagon emulsion used was 5 l.g. Nemagon 75% E.C. + 1.6 g. water

O Untreated

N 5 ml. per injection

2N 10 ml. per injection

Application:

1. One ring of 4 injections, 1 ft. from plant.
2. Two rings of injections: 1 ring of 4 injections at 1 ft. from plant plus 1 ring of 8 injections at 2 ft. from plant.

No. of applications:

- (i) Once a year — April 1959.
- (ii) Twice a year — April 1959, Jan. 1960.

FIRST RATOON CROP

Treatments		Ht. at shooting (inches)	Ht. Follower at shooting (inches)	Girth (diam.) (inches)	Grade (No. Hands)
Nemagon	1	136.7	63.6	7.18	8.11
Granules	2	137.4	64.9	7.17	8.20
(at planting)	3	138.4	65.2	7.29	8.35
	4	140.5	64.9	7.30	8.40
	5	137.2	63.4	7.16	8.15
Sign. Diff.		—	—	—	0.22*
Coeff. Var.		6.6%	11.1%	5.6%	6.1%
Nemagon	O	135.5	59.7	7.02	7.98
Injections	N	139.4	64.9	7.32	8.36
	2N	139.3	68.7	7.33	8.40
Sign. Diff.		0.9*	2.2*	0.06*	0.13*
Coeff. Var.		2.1%	10.3%	2.5%	5.0%
No. Rings	1	137.5	63.1	7.20	8.23
	2	137.0	65.7	7.24	8.26
Sign. Diff.		—	2.1*	—	—
Coeff. Var.		5.5%	12.8%	4.8%	6.1%
Applications	i.	138.4	64.9	7.23	8.26
	ii.	137.8	64.0	7.22	8.23
Sign. Diff.		—	—	—	—
Coeff. Var.		3.8%	8.5%	3.3%	4.3%

Path. 3.

NEMAGON INJECTION EXPERIMENT 3.

Layout: St. Catherine 4 Randomized Blocks. 2 Main Treatments
Irrigated. Lacatan. 3 Sub-treatments
Planted 12' x 12' double suckers.

D.D. Treatments:

Ring injections with D.D. all round individual mats, before being uprooted prior to re-planting, at approximately every 15" around each mat, at a distance of 6-9" from the mat with one in the centre — applied 25/2/59.

A. 10 ml. D.D. per injection.

B. Untreated.

Nemagon Treatments:

Applied 28/4/59. Bananas planted on same site in field as that occupied by A & B treated mats.

Injections: Nemagon 75% E.C. (5.2 I.g. N.E.C. + 1.6 I.g. water) in one ring of 4 injections 1 ft. from plant, one ring of 8 injections.

a. 5 ml. N.E.C./water per injection.

b. 10 g. Nemagon granules + 20 g. Gypsum in planting hole; 5 ml. N.E.C./water per injection.

c. Untreated.

Treatments		Height at shooting (inches)		Grade (No. Hands)	
		Plant Crop	Ratoon Crop	Plant Crop	Ratoon Crop
D.D.	A.	125	181	7.2	10.0
	B.	124	179	7.2	9.6
Sign. Diff.		—	—	—	—
C.V.		6.6%	4.5%	6.3%	6.4%
	a.	126	182	7.3	9.8
Nemagon	b.	124	178	7.2	10.0
	c.	122	180	7.2	9.7
Sign. Diff.		—	—	—	—
C.V.		2.6%	3.7%	2.8%	1.8%

NEMAGON INJECTION EXPERIMENT 4.

A. Layout: All-island trial. 33 Randomized Blocks. 3 Treatments. 100 plants per plot. Mostly Lacatan, a few Robusta plots.
Treatments:
Ring injections. 4 injections were in a ring 1 ft. from the plant and 8 injections in a ring 2 ft. from plant.
June/July 1959.
O Untreated
N 5 ml. NEC/water (25/75) per injection.
2N 5 ml. " " (50/50) " "

A. BUNCH RECORDS — GRADING

TREATMENT NEMAGON	AGE OF CROP	Count Bunch %				No. Hands per bunch			
		I	II	III	IV	I	II	III	IV
		48	49	55	57	6.75	6.56	6.85	6.99
	O	47	49	57	61	6.83	6.75	6.99	7.25
	N	47	52	59	63	6.81	6.89	7.09	7.30
	2N								
	Sign. Diff. P(0.001)					10.1%	9.6%	10.6%	0.29*
	C.V.								3.9%

B. GROWTH RECORDS

TREATMENT NEMAGON	AGE OF CROP	Total No. Bunches shot in 18 months from 100 mats.				Av. Height of shot plants (inches)				Av. Height of follower when bunch grades recorded (inches)				Av. Girth of shot plants (Diameter) (inches)			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
		78	114	133	126	103	120	122	135	40	56	57	62	6.3	6.7	6.7	7.3
	O	92	134	142	137	106	122	125	136	49	58	57	61	6.4	6.7	6.9	7.3
	N	89	137	147	141	105	124	127	140	49	55	57	58	6.4	6.8	7.0	7.3
	2N																
	Sign. Diff.	13.1**	7.8***	10.6***		5.8%	6.1%	4.9%	9.7%	6.5%	12.9%	9.6%	13.8%	4.2%	3.9%	5.6%	7.3%
	C.V.	47.5%	28.7%	16.1%	28.9%												

P,0.05*; P,0.01 **; P,0.001***

A.			
Average NUMBER OF BUNCHES shot, in quarterly periods of the year, expressed as a percentage of all the bunches shot between 1/7/59 and 31/12/60, in each individual plot of 100 mats.			
Quarterly Period		O	N 2N
July/Sept.	1959	13.6	13.4 12.6
Oct./Dec.	1959	14.5	13.4 18.4
Jan/March	1960	17.6	20.0 16.0
Apr/June	1960	16.7	16.0 18.0
July/Sept.	1960	20.7	20.4 21.0
Oct./Dec.	1960	17.6	16.6 16.0
Total No. Bunches shot		4,357	4,268 3,850

B.			
Average SIZE OF BUNCH (No. of hands) shot in quarterly periods of the year, expressed as a percentage of the average size of ALL bunches shot between 1/7/59-31/12/60 in each individual plot of 100 mats.			
Quarterly Period		O	N 2N
July/Sept.	1959	100	102 101
Oct./Dec.	1959	98	95 96
Jan/March	1960	96	95 96
Apr/June	1960	100	100 101
July/Sept.	1960	105	105 106
Oct./Dec.	1960	101	102 101
Av. No. Hands per bunch		7.04	6.96 6.69

Path. 5.

NEMAGON IRRIGATION EXPERIMENT

Layout: Rhymesbury. 2 Randomized Blocks — 4 Treatments. Plot size $\frac{1}{4}$ acre Gros Michel "plants".

Procedure: Total application of water per irrigation cycle was 3", applied at the rate of 1" per hour as follows:—

Treatments:

Irrigation by "Rainer" pipeline system. Started 10/8/59.

- A. $\frac{1}{2}$ hour water only to wet surface soil.
- B. 1 hour — Nemagon, 75% EC, for $\frac{1}{4}$ acre plot, 100 ml. per minute i.e. approximately 5 galls. per acre.
- C. $1\frac{1}{2}$ hours — water only to wash nemagon off foliage and deeper into soil.

Note. First application of Treatment 3. Block II. 18/6/59. Second application and other treatments from 10/8/59 onwards.

1. Nemagon — once a year, 10/8/59.
2. Nemagon — twice a year, 10/8/59, 14/3/60.
3. Nemagon — three times a year, 10/8/59, 8/2/60, 4/5/60.
4. Untreated — control.

Note. The plants in this experiment were Gros Michel, female parents — ref. Banana Breeding Report.

Treatments. Applications per year	Ht. at shooting (inches)	Days to shooting (1)	Days from shooting to reaping	Grades (No. Hands)	Wt. of Bunch (2)
1. Nemagon once	135	87	98	8.29	44.7
2. Nemagon twice	131	94	92	8.29	43.9
3. Nemagon three times	122	91	92	8.23	44.0
4. Untreated. Control.	119	88	94	8.25	43.1
Sign. Diff.	—	—	—	—	—
Coeff. Var.	11.5%	3.8%	1.6%	1.9%	3.2%

(1) Calculated from 1/2/60.

(2) Full grade, for seed collection.

Path. 6.

SHELL NEMAGON TRIAL 1. (M. O. LANE)

Layout. St. Catherine irrigated.

10 Randomized Blocks. 7 Treatments
Single plant plots. Plants 12' x 12' double suckers with an interplanted single sucker.
Lacatan, planted 6-11/7/60.

Treatments:

Ring injections. Applied 16 & 23/7/60. 5 ml. per injection of Nemagon/Water emulsion (1 in 5), at 8" depth.

- A. Untreated.
- B. 3 injections equidistant at 12" centre.
- C. 4 " at 12" centre.
- D. 4 " at 16" centre.
- E. 4 " at 20" centre.
- F. 4 " at 12" and 4 at 24".
- G. 4 " at 12" and 6 at 24".

Field not previously cropped in bananas for at least 20 years.

Application:

One block treated before irrigation and one after. First treatment 16/7/59. Only single suckers treated.

Treatment	Ht. at shooting (inches)	Ht. of follower at shooting (inches)	Girth (Diam.) (inches)	Grade (No. Hands)	No. Days to shooting
A	137	91	7.8	8.76	113
B	143	106	7.8	8.92	134
C	137	105	7.9	8.86	104
D	138	93	7.9	9.06	107
E	138	98	7.8	8.83	106
F	135	92	7.6	8.65	98
G	135	98	7.8	8.56	97
Sign. Diff	—	—	—	—	—
C.V.	1.67%	4.84%	2.18%	1.77%	24.5%

Path. 7.

SHELL NEMAGON TRIAL 2. (M. O. LANE)

Layout. St. Catherine
irrigated.

3 Randomized Blocks. 4 Treatments.
Plot size 45 sq. yds. Plants 12' x 12'
Lacatan.

Treatments:

Nemagon fed into flood irrigation water by constant flow apparatus from one point in the 'bund' around each plot.
Application 31/7/59

- A. Untreated Control.
- B. 3.0 I.g. Nemagon per acre, 4 I.g. 75% N.E.C.
- C. 3.5 I.g. " " " , 4.66 I.g., 75% N.E.C.
- D. 4.0 I.g. " " " , 5.33 " " "

Treatment		Ht. of shooting (inches)	Ht. of follower at shooting (inches)	Girth (inches)	Grade (No. Hands)	No. Days to shooting (1)	Wt. of bunch (2)
Control	A.	108.2	58.1	5.9	6.61	131	33.2
3.0 I.g. Nemagon	B.	115.0	59.9	6.2	7.02	128	32.7
3.5 I.g. Nemagon	C.	111.4	57.8	6.1	6.84	136	33.3
4.0 I.g. Nemagon	D.	115.6	62.4	6.0	7.07	125	32.7
Sign. Diff. P(0.01)		—	—	—	0.39	—	—
C.V.		2.6%	6.9%	2.8%	2.2%	9.5%	5.9%

(1) Calculated from 1/3/60.

(2) Calculated from mean wt. of 7 & 8 hand bunches weighed in each plot, due to incomplete data.

Path. 8.

SHELL NEMAGON TRIAL 3. (M. O. LANE)

Layout. St. Catherine
Irrigated.

Latin Sq. 4 Treatments. Split plots.
Planting 12' x 12' double suckers.
Planted 27/6/59. Lacatan.

Main Treatments:

Overall injection, 36 plants per treatment plot.

- A. Untreated
 - B. 3.0 I.g. per acre Nemagon
 - C. 3.5 I.g. " " Nemagon
 - D. 4.0 I.g. " " Nemagon
- First Applied 7-8/8/59.

(Sub-plot) **Injection distances:** 18 plants per treatment plot, 7-8/8/59.
12" injections overall.
20" injections overall.

(Sub-plot) **Retreatments:** 6 plants per treatment plot, 1-5/2/60.

- i. Untreated
- ii. 1.0 I.g. per acre Nemagon
- iii. 2.0 " " " "

Treatments	A.					B.		
	Ht. of shooting (inches)	Ht. of follower (inches)	Girth (inches)	Grade (No. hands)	No. weeks to shooting	No. weeks to shooting	No. days shooting to reaping	Wt. of Bunch
A	116	68	6.5	7.8	42	39	92	45.0
B	116	71	6.2	7.9	39	38	79	47.1
C	119	78	6.7	8.2	41	38	92	48.9
D	117	71	6.6	8.1	41	38	86	47.1
Sign. Diff.	—	—	—	—	—	—	—	—
C.V.	6.2%	23.2%	6.2%	6.8%	30.1%	27.9%	42.5%	12.1%
12"	117	72	6.6	8.0	40	38	91	47.1
20"	117	72	6.6	8.0	41	39	89	47.0
Sign. Diff.	—	—	—	—	—	—	—	—
C.V.	3.1%	19.0%	3.6%	3.5%	21.4%	12.6%	24.4%	5.1%
i.	116	71	6.5	8.0	94	—	—	—
ii.	116	70	6.6	8.0	97	—	—	—
iii.	118	75	6.6	8.0	107	—	—	—
Sign. Diff.	—	—	—	—	—	—	—	—
C.V.	4.4%	12.8%	3.7%	4.8%	19.6%	—	—	—

(A) Calculated from all bunch data.

(B) Calculated only from plants of which the bunches were weighed, insufficient bunches being weighed to provide data for effect of retreatments.

Path. 9.

SHELL NEMAGON TRIAL 4. (M. O. LANE)

Layout. St. Mary.

6 Randomized Blocks. 3 Treatments.
Plot size 2 Rows x 5 plots 9' x 9'. Lacatan.

Treatments. Overall injections, at 8" depth, 5 ml. injection.

- O. — Untreated — control
- A. — 3.5 I.g. Nemagon per acre. (4.66 I.g. 75% N.E.C.)
- B. — 5.0 I.g. " " " (6.66 I.g. 75% N.E.C.)

Treatment	Ht. at shooting (inches)	Ht. of follower at shooting (inches)	Girth (inches)	Grade (No. Hands)
O	107	63.96	5.6	6.14
A	108	65.30	5.9	6.62
B	105	63.31	5.7	6.36
Sign. Diff.	—	—	—	—
C.V.	5.0%	15.17%	10.3%	6.6%

Path. 10.

SHELL NEMAGON TRIAL 5. (M. O. LANE)

Layout. St. Mary.

6 Randomized Blocks. 5 Treatments.
Plot size one row of 15 plants, Lacatan,
10' x 10' spacing.Treatments: Ring injections. Applied 17/8/59. Plots 1-8.
All injections at 8" depth.A = Untreated — control.
B = 4 injections at 12": 4 injections at 24"
C = 4 injections at 12": 6 injections at 24"
D = 4 injections at 12": 8 injections at 24"
E = 6 injections at 12": 12 injections at 24"

Dilution of Nemagon was 4 of 75% EC to 11 of water (1 in 5)

Treatment	Ht. at shooting (inches)	Ht. of follower at shooting (inches)	Girth (diam.) (inches)	Grades (No. Hands)	Days to shooting
A	100	59	5.9	6.2	75.2
B	108	73	6.2	7.0	79.3
C	106	67	6.0	6.8	75.9
D	102	64	6.0	6.7	66.3
E	105	71	6.3	7.1	53.4
Sign. Diff. P(0.5) P(0.01)	5.53	10.5	—	0.5	—
C.V.	4.4%	13.1%	3.7%	4.6%	25.4%

Path. 11.

SHELL NEMAGON TRIAL 6. (M. O. LANE)

Layout: Portland.

7 Randomised Blocks. 3 Treatments.
Plants per plot = 10. Robusta, 10' x 10', single plants.

Treatments:

Overall injection 8" depth. 5 ml injection. Applied 24-25/8/59.

A = Untreated
B = 3.5 I.g. Nemagon/acre, 4.66 I.g. 75% N.E.C. per acre
C = 5.0 " " " 6.66 " " " " " "

Soil. Heavy clay friable on surface.

Treatment	Ht. at shooting (inches)	Ht. of Follower at shooting (inches)	Girth (Diam.) (inches)	Grade (No. hands)
A	100	30.6	6.5	7.0
B	96	32.1	6.3	7.0
C	97	34.9	6.3	7.0
Sign. Diff.	—	—	—	—
C.V.	9.0%	18.8%	2.8%	5.6%

Path. 12. SHELL NEMAGON TRIAL 7. (C. W. MCBETH)

LAYOUT. St. Catherine
Irrigation.

3 Randomised Blocks. 3 Treatments.
Planted July 1958.
Plot size 64 plants. 4 Rows, 12' x 12',
double suckers, Lacatan.

Treatments:

Nemagon fed into flood irrigation water by constant flow apparatus from one point in the 'bund' around each plot.

Application 30/4/59.

A. Untreated — control.

B. 2.5 U.S.g. Nemagon per acre.

C. 5.0 U.S.g. Nemagon per acre.

Treatment	PLANT CROP				FIRST RATOON CROP				
	Ht. at shooting (inches)	Ht. Follower at shooting (inches)	Grade (No. Hands)	Days to shooting (1)	Ht. at shooting (inches)	Ht. Follower at shooting (inches)	Grade (No. Hands)	Wt. of Bunch (lb)	Date of shooting (2)
A	104	47	7.06	116	131	51	7.41	33.6	138
B	106	49	7.25	110	139	58	7.93	37.5	119
C	104	46	7.28	109	142	61	8.20	40.3	122
Sign. Diff. (P.0.01)	—	—	—	—	2.19	—	0.46	—	—
C.V.	2.1%	4.7%	2.4%	9.3%	0.4%	4.4%	0.9%	11.8%	5.6%

(1) Calculated from 1/2/59 (2) Calculated from 1/11/59.

Path. 13.

LATEX STAIN EXPERIMENT 1.

Latex flow off fingers from which styles were broken on bunches hanging in the field.
Layout: 6 Randomised Blocks

5 Treatments — age of bunch
2 Subtreatments — time of day

Main Treatments

A Bunch just fully open
B Bunch open 1-20 days
C " " 21-40 "
D " " 41-60 "
E " " over 60 days

Subtreatments

(1) Styles broken 7.15-9.15 a.m.
(2) " " 10.30-12.30 p.m.

Method:

Bunches held so that fingers were horizontal when styles were broken.
Styles broken off three fingers of each bunch at both times of day.

Mean time taken, in seconds, for first drop of latex to fall from finger

Age of bunch

		A	B	C	D	E	Mean	Sign. Diff.	C.V.
Time of day	1	65.9	60.7	47.3	30.7	24.8	45.9	P(0.01)	45.1%
	2	102.2	100.1	83.1	52.7	31.2	73.9	10.6	
Mean		84.0	80.4	65.2	41.7	28.0			
Sign. Diff.		P(0.01)=	27.6	P(0.05)=	19.5				
C.V.				54.3%					

Path. 14.

LATEX STAIN EXPERIMENT 2.

Latex flow off fingers from which styles were broken on the reaped bunches stacked horizontally in field stands.

Layout: 12 Random bunches 19/10/60

Styles broken on 6 bunches 8.00 a.m.— 8.45 a.m. (A)
" " " 6 bunches 11.30 a.m.—12.15 p.m. (B)

3 Styles broken on each bunch

Records:

(I) Time taken for each drop to fall.
(II) No. Drops to fall in 3 minutes

I Mean

No. seconds for 1st
2 drops to fall from
each style.

II Mean

No. drops which
fell from one
style.

		No. Seconds	C.V.
Time of	A	62.08	18.9%
Day	B	102.08	71.0%
Sign. Diff.			
P(0.02)		37.25	
C.V.		26.3%	

		No. Drops	C.V.
Time of	A	3.67	20.0%
Day	B	2.33	18.7%
Sign. Diff.			
P(0.01)		1.05	
C.V.		19.2%	

P.B. 3.

TETRAPLOIDS IN THE NURSERY AND SELECTIONS

Male Parent	T16	T23	T25	T27	T28	T36	T39	T40	T42	T43	T45	T47	T52	T53	T54	T58	T59	T60	T61	T62	Total
Gros Michel																					
On Hand	1	4	1	51	2	-	-	1	-	-	2	1	-	-	-	-	-	-	-	-	63
Planted Out	-	-	-	29	-	23	1	-	8	1	-	-	20	29	10	18	11	1	12	13	176
Discarded	1	2	1	45	1	5	-	1	-	-	2	-	4	3	2	-	-	-	-	-	67
Selected	-	2	-	10	-	-	-	-	-	1	-	1	2	1	-	-	-	-	-	-	17
Remaining	-	-	-	25	1	18	1	-	8	-	-	-	14	25	8	18	11	1	12	13	155
Highgate																					
On Hand	-	-	-	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26
Planted Out	-	-	-	16	-	4	-	-	-	-	-	-	-	6	-	3	-	-	-	-	29
Discarded	-	-	-	31	-	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	35
Selected	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Remaining	-	-	-	5	-	1	-	-	-	-	-	-	-	5	-	3	-	-	-	-	14

P.B. 4.

PANAMA DISEASE TESTING

Cross	On Hand	Planted Out	Selected	Discarded	Remaining
G.M. x T16	1	-	-	1	-
G.M. x T23	3	2	1	3	1
G.M. x T25	1	-	-	1	-
G.M. x T27	1	10	-	6	5
G.M. x T31	1	-	-	1	-
G.M. x T43	-	1	-	-	1
G.M. x T47	-	1	-	-	1
G.M. x T52	-	2	-	-	2
G.M. x T53	-	1	-	-	1
H.G. x T27	-	6	-	-	6
Total	7	23	1	12	17

Cyto. 1 YIELDS FROM GM X T27 IN VARIOUS FIELDS AT BODLES AND RHYMESBURY

Field	Bunches	Fertile	Seeds	Mean seeds	Mean hands	Bchs. with 10 + seeds	Most in one bunch
Bodles							
1	2	2	3	(10.5)		0	7
4	94	20	45	5.98		3	27
7	188	39	128	5.63		0	6
8	78	28	65	6.95		1	12
9	99	24	56	6.95		0	8
10	737	191	380	6.50		2	16
11	523	92	215	6.40			
Sum	1721	396	892	6.40			
Rhymesbury							
12	1459	261	469	6.73		5	11
13	181	87	191	8.30		2	12
Sum	1640	348	660	6.90			
Grand Total	3361	744	1552	6.46			

Cyto. 2. SEEDS PER BUNCH AND HANDS PER BUNCH FROM CROSSES PERFORMED ON THIRTY OR MORE BUNCHES, IN EACH GROS MICHEL FIELD AT RHYMESBURY, EXCEPTING X T27

Male	Field 12			Field 13			Field 14			Most in a bunch
	Bunches	S/B	H/B	Bunches	S/B	H/B	Bunches	S/B	H/B	
T34	151	0.17	6.66	609	0.48	7.91	78	0.53	7.81	5
T35	181	0.09	5.99	36	0.17	7.19				9
T36										8
T39	55	0.13	6.15				709	0.22	8.06	6
T42							75	2.12	8.04	21
T47	62	0.05	6.81	283	1.07	8.29	100	0.31	8.33	35
T52				370	0.40	7.99	648	0.41	8.23	21
T53	30	0.20	7.17	204	1.08	8.10				8
T54				776	0.38	7.50	93*	0.06	8.01	41
T58	33	0.06	5.91				315	0.30	8.02	19
T59							286	1.45	8.34	9
T61							227	0.67	8.26	43
T62										10

* Most T58 crosses were pollinated at an abnormal hour in a seed production trial

Cyto. 3.

**MORE PRECISE POLLEN COMPARISONS; PAIRS OF CROSSES MADE
SIMULTANEOUSLY BY THE SAME OPERATOR**

Month(s)	Comparison	First Pollen				Second Pollen			
		Bunches	Seeds	S/B	H/B	Bunches	Seeds	S/B	H/B
	Field 13								
4-5/59	T27 v T52	159	180	1.13	8.31	160	168*	1.05	8.35
5-7/59	T52 v T54	222	243	1.09	8.23	168	144	0.86	8.17
3-4/60	T36 v T54	103	60	0.58	7.59	31	74‡	2.39	7.74
3-8/59	T36 v T53	448	190	0.42	8.07	306	136	0.40	8.19
1/60	T39 v T58	32	6	0.19	7.22	78	8	0.10	8.81
	Field 14								
3-4/60	T59 v T62	157	61	0.39	8.20	212	144	0.68	8.27
3-5/60	T61 v T62	276	340	1.23	8.34	142	115	0.81	8.31
4-5/60	T52 v T53	98	31	0.32	8.33	352	135	0.38	8.27
5/60	T34 v T53	38	13	0.34	7.44	61	21	0.34	8.07

* One bunch of x T52 had 21 seeds

‡ One bunch of x T54 had 41 seeds

Cyto. 4.

SEED YIELDS FROM HIGHGATE CROSSES

Field	Male	Bunches	Fertile	Seeds	Mean seeds	Mean hands	Most in a bunch
1	PL	614	164	469*	0.76	9.89	18
	T1	70	28	88	1.26	9.96	11
	Other	26	2	6	0.23	9.96	
		710	194	563	0.79	9.90	
12	T27	144	40	137	0.95	8.52	28
	Other	57	2	2	0.04	7.54	
		201	42	139	0.69	8.24	
13	T36	48	7	11	0.23	9.60	
	T53	105	13	21	0.20	9.30	
	T58	143	13	28	0.20	8.84	
	Other	69	6	7	0.10	9.51	6
		365	39	67	0.18	9.24	
14	Various	183	11	12	0.06	9.32	
Total Rhymesbury		749	92	218	0.29		

* This included 42 obviously bad seeds, an unusually high proportion

Cyto. 5.

* Seeds sown to 30/6/60

Cyto. 6.

* Cross discontinued and no seeds after this date

STAFF AT 31st DECEMBER, 1960.

Director & Plant Pathologist	..	R. Leach, M.A., A.I.C.T.A.
Crop Physiologist		E. A. Tai, M.Sc., D.I.C.T.A.
Agronomist		V. R. Lumsden, B.A., Dip. Agr. (Cantab).
Soil Chemist		C. G. Jordine, B.Sc., A.R.I.C.
Asst. Plant Pathologist		D. S. Meredith, M.A., Ph.D., M.I.Biol.
Analyst		Mrs. D. E. Boland, B.Sc.
Executive Field Officer		W. G. Chambers.
Secretary		Miss B. McLean.
Stenographer/Typists		Miss V. Green, Miss O. Vaz, Miss E. Latibeaudiere.
Computers		Miss J. Thomas, Miss G. Perkins.
Technical Assistants		Miss J. Lai, Miss C. Gray, R. Chen, F. Lumsden, J. O. Creary, O. Atkinson, R. Allen.
Field Officers		H. H. Christie, G. L. McKenzie, J. A. Morris, L. R. Crombie, S. E. Crooks, W. J. Small, S. L. Ellis.
Handymen to Field Officers		V. Powell, R. Bartley, D. Gray, R. Peynado, D. Hartley, R. Hylton, C. Morrison.
Handymen (Head Office)		K. Watson, J. James, M. Robinson.
Laboratory Cleaners		I. Braham, E. Brown, M. Campbell.

Banana Breeding Scheme:

Plant Breeder		R. E. Osborne, D.I.C.T.A., Dip. Agr. (Reading).
Cytogeneticist		K. Shepherd, B.Sc.
Senior Station Officer		R. A. Gonsalves, B.Sc.
Clerical Assistant		Miss A. J. Hilton.
Stenographer/Typist		Miss Y. Z. Henry.
Technical Assistant		H. J. Anderson.
Headman		J. Cohen.
Handyman		B. Grant.
Laboratory Cleaner		L. Scott.

